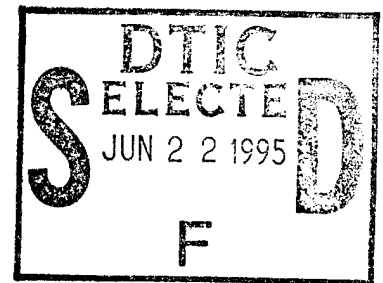


IMPLEMENTATION DOCUMENT
FOR OTHER CONTAMINATION SOURCES
INTERIM RESPONSE ACTION
SHELL SECTION 36 TRENCHES, RMA



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| VOLUME 1 | GENERAL |
| VOLUME 2 | SPECIFICATIONS |
| VOLUME 3 | DRAWINGS |

FINAL

March 1991

Prepared by
Morrison-Knudsen Corporation
Environmental Services Group
Denver, Colorado 80203

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Prepared for
Shell Oil Company
Denver, Colorado 80203

**Rocky Mountain Arsenal
Information Center
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VOLUME 1 GENERAL

FINAL

March 1991

Prepared by
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1.0 INTRODUCTION

The Interim Response Action (IRA) for the Shell Section 36 Trenches is being conducted as part of the IRA Process for the Rocky Mountain Arsenal (RMA) in accordance with the June 5, 1987 report to the court United States v. Shell Oil Company and the Federal Facility Agreement effective February 17, 1989.

The Decision Document for the Shell Section 36 Trenches IRA became final in April 1990. The detailed design presented herein incorporates the concepts proposed in Section 6.0 of the Final Decision Document, based on additional data developed following preparation of the Final Decision Document. The conceptual design was issued as a Preliminary Engineering Design Package on October 5, 1990 for review and comment by the Organizations and State. Comments from this review were discussed at a meeting of the Organizations and State on October 26, 1990. Written comments from the USEPA and State were submitted to Shell on October 24, 1990 and October 31, 1990, respectively. Written responses to comments were submitted by Shell to the Organizations and State in December 1990. The Draft Implementation Document for this IRA was submitted by Shell on December 19, 1990.

A description of the activities for this IRA is included in this section. A construction cost estimate and schedule have been prepared and are included. The cost of construction is estimated to be \$1,775,000 and the basis of the estimate is given in Section 4. The deadline for completion of this project (an "IRA Deadline" under the Federal Facility Agreement) is December 21, 1991, subject to extension as described in Section XXVI of the Federal Facility Agreement. Intermediate dates shown in this document comprise the "Schedule" (as defined in the Federal Facility Agreement) and are not "Deadlines" under the Federal Facility Agreement.

The Shell Section 36 Trenches IRA will consist of the following:

1. Construction of a temporary service road extending from the fill source area and west of the Hydrazine Blending Facility to December 7th Avenue. This service road will not be removed as part of this IRA, since the road is intended also for use in earthwork construction projects following construction for this IRA.
2. Upgrade of the existing service road extending north from December 7th Avenue along the eastern margin of the proposed earth cover over the Shell Trenches. Upgrading includes reestablishment, using clean fill, of portions of the road on the eastern side of the earth cover.
3. Installation of an approximately rectangular slurry wall that surrounds the Shell Trenches. The slurry wall will be keyed into the Denver Formation on the northern, western, and north half of the eastern sides of the slurry wall and into the eluvial clay unit of the alluvium on the southern and south half of the eastern sides of the slurry wall. The slurry wall will be constructed using the vibrating beam injection method.
4. Construction of an earth fill cover over the area surrounded by the slurry wall and areas south of the trenches where land surface depressions exist. Roughly the bottom 12-inches of the cover will consist of compacted fill, while roughly the uppermost 20 inches will consist of uncompacted fill suitable for supporting a vegetative cover. It is estimated that up to approximately 62,000 cubic yards of fill will be

borrowed from the eastern sediment stockpile near the Hydrazine Blending Facility to construct the cover.

5. Final grading to establish adequate surface water drainage. Outside of the area surrounded by the slurry wall, there will be minor earth cuts at several locations.
6. Placement of soil amendments, crested wheatgrass seed, and material for erosion protection over all areas disturbed during construction, except for the service roads and borrow area.
7. Installation of six soil moisture monitoring stations; both within the area surrounded by the slurry wall and outside the slurry wall perimeter. Each station will be used to evaluate the variation in soil moisture with depth in the plant root zone.
8. Abandonment of fifteen existing alluvial and Denver Formation groundwater monitoring wells and ten well points, all of which are either located within the area of the proposed earth cover or have poor or questionable construction. Wells to be abandoned that are outside of the cover area are located both upgradient and downgradient of the Shell Trenches.
9. Installation of seven alluvial groundwater monitoring wells screened in either the eluvial clay or the eolian sand unit. These wells will be installed and sampled both to monitor groundwater quality in the dissolved plume and to confirm the presence or absence of DNAPL at each well location. Dissolved plume monitoring will consist of collection and analyses of groundwater samples at a semi-annual frequency. The analyte list

includes pesticides, organosulfur compounds, DBCP, DIMP/DMMP, and volatile organics.

10. Installation of five pairs of permanent piezometers adjacent to the slurry wall surrounding the Shell Trenches.

MEMORANDUM OF UNDERSTANDING BETWEEN
THE DEPARTMENT OF THE ARMY AND SHELL OIL COMPANY
WITH RESPECT TO
RESPONSE ACTION WORK CONDUCTED PURSUANT TO THE
FEDERAL FACILITY AGREEMENT

I. PARTIES

This Memorandum of Understanding ("MOU") specifies the cooperative undertakings which are to occur between the Army (a potentially responsible party under CERCLA) and Shell (a potentially responsible party under CERCLA) with respect to any Scope of Work developed pursuant to the Federal Facility Agreement now or hereafter attached as an exhibit to this MOU.

II. PURPOSE

The purpose of this MOU is to provide an appropriate basis pursuant to the Federal Facility Agreement for Shell to participate in the expeditious (a) assessment, selection, design and implementation of an IRA or (b) operation and maintenance of any Response Action Structure.

III. DEFINITIONS

The following terms, used in the MOU, shall have the meanings indicated:

(a) "Army" means the United States Department of the Army, and any successors or assigns thereof, and any agency, office or other subdivision thereof; and includes the officers, members, employees and agents of the Army when acting within the scope of their authority.

(b) "Arsenal" means the United States property known as the Rocky Mountain Arsenal and described more particularly on Exhibit A hereto.

(c) "CERCLA" means the Comprehensive Environmental Response, Compensation and Liability Act of 1980, as amended by the Superfund Amendments and Reauthorization Act of 1986.

(d) "Contractor" means any commercial party not a part of Shell with which Shell contracts for the performance of Response Action work pursuant to this MOU. Unless otherwise indicated, the term also includes a subcontractor retained by a prime Contractor or another subcontractor.

(e) "Federal Facility Agreement" means the Federal Facility Agreement for Rocky Mountain Arsenal, effective February 17, 1989, including all exhibits thereto (and any amendments or modifications thereof or supplements thereto).

(f) "Financial Manual" means the document identified in paragraph 7.4 of the Settlement Agreement.

(g) "Force Majeure" means any event arising from causes beyond the control of an Organization that causes a delay in or prevents the performance of any obligation under this MOU. "Force Majeure" includes, but is not limited to: acts of God; fire; war; insurrection; civil disturbance; explosion; unanticipated breakage or accident to machinery, equipment or lines of pipe, despite diligent maintenance; adverse weather conditions which could not be reasonably anticipated; unusual delay in transportation; earthquakes; restraint by court order or order of public authority; inability to obtain, at reasonable cost and after exercise of reasonable diligence, any necessary authorizations, approvals, permits or licenses as a result of the action or inaction of any governmental agency or authority other than the Army; delays caused by compliance with applicable statutes or regulations governing contracting, procurement or acquisition procedures, despite the exercise of reasonable diligence; and insufficient availability of appropriated funds, if the Army shall have made timely request for such funds as part of the budgetary process. "Force Majeure" also includes any strike or labor dispute, whether or not within the control of the Organization affected thereby, but shall not include increased costs or expenses of Response Actions, whether or not anticipated at the time such Response Actions were initiated.

(h) "IRA" means an Interim Response Action identified in Section XXII of the Federal Facility Agreement.

(i) "Lead Party" means the Organization that is designated with responsibility, in accordance with Section XLIII of the Federal Facility Agreement, for conducting a Response Action, or any part thereof.

(j) "MOU" or "Memorandum of Understanding" means to this entire document and any amendments or modifications hereof and supplements hereto, and all documents incorporated herein by reference.

(k) "NCP" means the National Oil and Hazardous Substances Pollution Contingency Plan, 50 Fed. Reg. 47912 (1985) (effective February 18, 1986), and all amendments thereto which are not inconsistent with CERCLA and which are effective and applicable to any activity undertaken pursuant to this MOU.

- (l) "Organization" means the Army, EPA or Shell.
- (m) "Party" means the Army or Shell; "Parties" means the Army and Shell.
- (n) "Response Action" has the same meaning as "Respond" or "Response" as defined in Section 101(25) of CERCLA, 42 U.S.C. § 9601(25).
- (o) "Scope of Work" means a document identified in Part VI by which any Response Action work for which Shell is the Lead Party shall be conducted.
- (p) "Settlement Agreement" means the "Settlement Agreement Between the United States and Shell Oil Company Concerning Rocky Mountain Arsenal," effective February 17, 1989, including all exhibits thereto (and any amendments or modifications thereof or supplements thereto).
- (q) "Shell" means (a) Shell Oil Company and its successors and assigns, (b) the divisions thereof, including Shell Chemical Company, (c) Julius Hyman & Co., and (d) Shell Chemical Corporation; and includes the officers, employees and agents of Shell when acting within the scope of their authority.

All other capitalized terms used in this MOU shall have the same meaning as in the Federal Facility Agreement or the Settlement Agreement or the meaning specified in an executed Scope of Work.

IV. SCOPE OF MOU

This MOU, the Federal Facility Agreement and the Settlement Agreement constitute the entire understanding between the Army and Shell with respect to Shell's assisting the Army in the Response Action work described in an executed Scope of Work, except for any subsequently executed Scope of Work which the Parties may execute with respect to such Response Action work; constitute the sole conditions controlling Shell's participation in such Response Action work; and with respect to such Response Action work, supersede any other agreement(s) between the Parties. In the event a conflict between the provisions of the Federal Facility Agreement and the Settlement Agreement and this MOU, the provisions of the Federal Facility Agreement and the Settlement Agreement shall govern.

V. OPERATION OF MOU

By their execution of this MOU, each of the Parties acknowledges and agrees as follows:

(a) The provision of the Response Action work pursuant to this MOU is a reasonable and appropriate contribution to the assessment, selection, design and implementation of Response Actions that are protective of the present and future public health and the environment.

(b) The Army's actions under this MOU are not inconsistent with the NCP.

(c) Shell's actions under this MOU, to the extent certified by the Army pursuant to Subpart VI.E., are consistent with the NCP.

(d) This MOU does not operate to establish or to excuse any Shell or Army liability under any law, the Federal Facility Agreement or the Settlement Agreement, except to the extent provided in this MOU.

(e) This MOU does not operate to render Shell or any of its Contractors a CERCLA response action contractor.

(f) This MOU does not operate to expand or limit any of the rights and obligations of the Army as Lead Agency or Shell as Lead Party under any law or the Federal Facility Agreement.

(g) Unless otherwise provided in a Scope of Work, upon acceptance of the Response Action work pursuant to Subpart VI.E. title to any Response Action Structures including all related systems and facilities constructed as a part of that Response Action work shall pass to the United States.

(h) The Army shall be solely responsible for obtaining necessary permits, if any, and for establishing substantive compliance with all permitting requirements pursuant to Section 121(e) of CERCLA, 42 U.S.C. 9621(c), for any activities conducted pursuant to this MOU. However, Shell shall provide any necessary technical support necessary for the Army to obtain such permits.

(i) This MOU has no precedential or controlling effect with respect to any matter which is not expressly the subject of this MOU.

(j) This MOU does not create or impose any obligations or responsibilities on the Parties or relieve them of any obligations or responsibilities, except to the extent expressly provided herein.

VI. SHELL'S PERFORMANCE OF RESPONSE ACTION WORK.

A. Development of Scope of Work: Pursuant to Section XLIII of the Federal Facility Agreement, the Army and Shell shall develop Scopes of Work by which Response Action Work for which Shell is the Lead Party shall be conducted. A Scope of Work shall include any required data or specifications for the Response Action work to be performed, a projected schedule for completion and a statement as to the appropriate limits of insurance to be maintained by Shell pursuant to Part VII.

B. Incorporation into this MOU: Any Scope of Work developed pursuant to Subpart VI.A and executed by the Army and Shell, and all the terms and conditions therein are incorporated by reference into this MOU.

C. Performance of Work: Upon execution of the Scope of Work by the Army and Shell, Shell shall immediately commence, in consultation and cooperation with the Army, as provided in the Consent Decree, to perform the Response Action Work described in the Scope of Work.

D. Hiring of Contractor: Subject to the approval of the Army, Shell may hire at its sole expense, subject to Part VII, a Contractor to perform any Response Action work described in a Scope of Work. A Contractor may be terminated by Shell with the approval of the Army, which approval shall not be unreasonably withheld. Any disagreement with respect to such termination not resolved informally shall be resolved in accordance with the provisions of Part XIII.

E. Acceptance of Work: 1. If Shell performs the Response Action work in accordance with the specifications set forth in the applicable Scope of Work, the Army shall accept Shell's work pursuant to this MOU. The Army shall act promptly to accept Shell's work, and acceptance shall not be unreasonably withheld. Should the Army decline acceptance, it shall promptly notify Shell in writing, stating with specificity the factual, technical and legal bases for such nonacceptance.

2. If Shell concludes that the Army is in error for treating Shell's performance as incomplete or unacceptable for any other reason, Shell shall give notice in writing, within ten business days of the receipt of the Army's written notification, that Shell disagrees. Any such disagreement, if not resolved informally, shall be resolved in accordance with the provisions in Part XIII.

VII. SHELL INSURANCE OBLIGATIONS

Shell shall maintain such insurance or self-insurance as is required by statute or regulation to cover any claims which may reasonably be anticipated to be made as a result of Response Action work done pursuant to any Scope of Work attached as an exhibit to this MOU. At a minimum, Shell shall, at its sole option, procure insurance, maintain insurance or self-insure sufficiently to cover the following:

1. Worker's compensation and occupational disease insurance in amounts sufficient to satisfy applicable state law;
2. Employer's liability insurance in the minimum amount of \$100,000 per occurrence; and
3. Comprehensive general liability insurance for bodily injury, death or loss of or damage to property of third persons in the minimum amount of \$100,000 per occurrence.

Upon this MOU becoming effective, Shell shall promptly provide the Army with an affidavit that Shell is in compliance with the minimum requirements of this Part. Upon the signing of a Scope of Work, Shell shall promptly provide the Army with an affidavit that Shell is in compliance with this Part as to that Scope of Work. Upon request, Shell shall discuss with the Army the manner in which Shell will fulfill its obligations under this Part.

VIII. ARMY SUPPLEMENTATION OF SHELL INSURANCE

If the Response Action work being performed is an Army-Only Response Action, as defined in the Settlement Agreement, the Army shall release, defend, indemnify and hold harmless Shell from all losses, fines, penalties, claims, suits, liabilities, judgments, or expenses (including expenses of litigation or settlement) (collectively hereinafter in this Part VIII, "claims") with respect to any death or injury to any person or loss of or damage to property to the extent that these result from the construction, operation, collapse, rupture or failure of any Response Action Structure, or any part thereof, after the Army's acceptance pursuant to Subpart VI.E. or the operation, collapse, rupture, failure or ineffectiveness of the Response Action Structure as a result of the construction, operation, collapse, rupture or failure of the Response Action work when such claim is not compensated by insurance or self-insurance, to the extent provided below:

- (a) Shell is not in material breach of this MOU with respect to the Scope of Work pursuant to which such Response

Action work was performed or such Response Action Structure was constructed:

(b) Any claim which is within the deductible amounts of Shell's insurance shall not be subject to this Part:

(c) Shell shall not be reimbursed for any claims (including expenses incidental to such claims) to the extent that they result, in whole or in part, from willful misconduct or recklessness by Shell:

(d) The Army may discharge its obligations under this Part by making payments directly to Shell or directly to any party to whom Shell may be liable upon obtaining a release from that party, which release provides adequate protection for Shell.

(e) If insurance coverage maintained in accordance with Part VII is reduced below the minimums specified in that Part without the Army's knowledge or approval, the liability of the Army under this MOU shall not be increased by reason of such reduction:

(f) To the extent that any claim against Shell may reasonably be expected to involve indemnification under this Part, Shell shall:

(1) promptly notify the Army of such claim against Shell:

(2) furnish evidence or proof of any claim covered by this Part in the manner and form reasonably requested by the Army; and

(3) immediately furnish the Army with copies of all pertinent papers received by Shell.

(g) To the extent that the amount of the claim is not determined to be in excess of the limits set forth in Part VII or to the extent that the amount of the claim cannot reasonably be determined to be or not to be in excess of those limits, Shell and the Army shall conduct a joint defense or settlement. Once it is determined that the amount of the claim is in excess of the limits set forth in Part VII, the Army shall direct and control such defense or settlement, with assistance by Shell as is acceptable to both Parties, and Shell shall execute any authorizations which the Army reasonably requires in connection with such settlement.

(h) Reimbursement for any claims under this Part shall not exceed appropriations available during the time that

such claims are represented by final judgments or by settlements approved in writing by the Department of Justice. This agreement to reimburse Shell for certain claims shall not be interpreted as implying that Congress shall, at a later date, appropriate funds sufficient to meet any deficiencies. During all times that claims remain unreimbursed due to lack of appropriated funds, the Army shall exert its best efforts to obtain appropriations for such reimbursement.

**IX. TREATMENT OF COSTS INCURRED
BY SHELL PURSUANT TO THIS MOU**

Any costs incurred by Shell pursuant to this MOU are Reimbursable Costs and shall be governed by the Settlement Agreement and the Financial Manual.

X. DELAY OR PREVENTION OF PERFORMANCE

A. As provided in the Consent Decree, if a Party is rendered unable, wholly or in part, by Force Majeure to carry out its obligations under this MOU, then upon that Party's giving written notice as provided in Subpart XI.C., the obligations of that Party, so far as they are affected by the event of Force Majeure therein specified, shall be suspended during the continuance of such cause, but for no longer period, and such cause shall be remedied so far as possible with all reasonable dispatch.

B. The settlement of a strike or other labor dispute shall be entirely within the discretion of the Party involved with such strike or labor dispute, and the requirement that any event of Force Majeure shall be remedied with all reasonable dispatch shall not require the settlement of a strike or labor dispute by acceding to the demands of the opposing party when such course is inadvisable in the discretion of the Party involved with such strike or labor dispute.

C. When circumstances are occurring or have occurred that delay the completion of any obligation, and a Party believes such circumstances constitute an event of Force Majeure, such Party shall notify the other Organizations in writing within 15 days after the notifying Party obtains information indicating that a delay will occur. Such notice shall include a detailed explanation of the reason(s) for and anticipated duration of the delay, the measures taken and to be taken to prevent or minimize the delay, and a schedule for implementation of such measures. Failure to provide notice in accordance with this paragraph within the required 15-day period shall constitute a waiver of any claim of Force Majeure with respect to any event of Force Majeure for which notice was not timely given.

D. If the Organizations cannot agree whether a delay is or was attributable to an event of Force Majeure, any Organization may invoke Dispute Resolution pursuant to Section X of the Settlement Agreement.

E. Scope of Work Modification: If performance of this MOU is delayed because any Party finds it necessary to make modifications to address an unanticipated occurrence which may cause a delay of more than two weeks, such modifications shall be developed and implemented by Shell in consultation and cooperation with the Army. Any disputes not resolved informally shall be resolved pursuant to the provisions of Part XIV. Further, if Shell anticipates the delay resulting from any such modifications will necessitate the extension of a Deadline, it shall request such an extension in accordance with Section XXVI of the Federal Facility Agreement.

F. Unaffected Activities: To the extent that the unanticipated occurrence does not necessitate delay in any discrete portion(s) of the activities provided in Part VI, such portion(s) of the activities shall proceed as originally provided in the MOU irrespective of the need for modification of other parts of the MOU.

XI. SHELL ACCESS TO ROCKY MOUNTAIN ARSENAL

Shell and its Contractors shall be afforded access to all relevant portions of the RMA in order to perform its obligations under the MOU pursuant to the terms and conditions of the Access and Use Agreement attached as Exhibit E to the Settlement Agreement until such time as the Army and Shell execute an applicable superseding agreement.

XII. DISPUTE RESOLUTION AND JUDICIAL REVIEW

A. Dispute Resolution: Any dispute which arises in connection with this MOU may be submitted for resolution pursuant to Section X of the Settlement Agreement. Prior to any such submission, Shell and the Army shall meet and attempt to resolve the dispute informally.

B. Judicial Review: 1. Judicial review of issues arising in connection with this MOU shall be obtained pursuant to Section XI of the Settlement Agreement.

2. The pendency of any dispute shall not affect the responsibility of the United States or Shell to continue their involvement in the assessment, selection, design and implementation of Response Actions, or discrete portions of Response Actions, not subject to such dispute.

XIII. GENERAL

A. Term: This MOU shall continue in effect as to a specific Scope of Work until the Army, pursuant to Subpart VI.E., accepts Shell's work pursuant to this MOU, and the reimbursement or payment has been made pursuant to Part IX.

B. Modification: Any provision of this MOU or of any Scope of Work may be modified at any time by both Parties' agreement. Any modification must: (1) be in writing; (2) show the date signed by the Parties; (3) specify that it is intended to modify this MOU; (4) state the provisions of the MOU to be modified; (5) state the new provisions; and (6) state when the new provisions are to be effective.

C. Effect of Execution: This MOU shall become effective on the later of its execution by the Parties or the entry of the Consent Decree. A Scope of Work shall become effective, final and binding upon its execution.

IN WITNESS WHEREOF, I have hereunder set my hand as an authorized representative of the United States Department of the Army.

Date: 1/23/89

Lewis D. Walker

Lewis D. Walker
Deputy for Environment, Safety
and Occupational Health

IN WITNESS WHEREOF, I have hereunder set my hand as an authorized representative of Shell Oil Company.

Date: _____

R.G. Dillard
Vice President

XIII. GENERAL

A. Term: This MOU shall continue in effect as to a specific Scope of Work until the Army, pursuant to Subpart VII.E., accepts Shell's work pursuant to this MOU, and the reimbursement or payment has been made pursuant to Part IX.

B. Modification: Any provision of this MOU or of any Scope of Work may be modified at any time by both Parties' agreement. Any modification must: (1) be in writing; (2) show the date signed by the Parties; (3) specify that it is intended to modify this MOU; (4) state the provisions of the MOU to be modified; (5) state the new provisions; and (6) state when the new provisions are to be effective.

C. Effect of Execution: This MOU shall become effective on the later of its execution by the Parties or the entry of the Consent Decree. A Scope of Work shall become effective, final and binding upon its execution.

IN WITNESS WHEREOF, I have hereunder set my hand as an authorized representative of the United States Department of the Army.

Date: _____

Lewis D. Walker
Deputy for Environment, Safety
and Occupational Health

IN WITNESS WHEREOF, I have hereunder set my hand as an authorized representative of Shell Oil Company.

Date: 2/15/89

R.C. Dillard
R.C. Dillard
Vice President

SCOPE OF WORK

Shell will perform the following activities as lead party for design and implementation of the Shell Section 36 Trenches IRA:

1. Perform the preliminary investigation and engineering required to develop a Preliminary Engineering Design Package for review and approval by the Army.
2. Prepare the Draft and Final Implementation Documents for review and approval by the Army and implement the Shell Section 36 Trenches IRA.
3. Perform detailed design of the selected system, based upon the agreed specifications, which will be in conformance with the selected alternative set forth in the Final Decision Document and including the following:
 - a. Temporary service road extending from the fill source area (eastern stockpile of sediment excavated during the Lower Derby Lake embankment and spillway construction) and west of the Hydrazine Blending Facility to December 7th Avenue. The service road will not be removed as part of this IRA.
 - b. Permanent service road extending north from December 7th Avenue along the eastern margin of the proposed earth cover over the Shell Trenches.
 - c. Slurry wall surrounding the Shell Trenches that is keyed into the Denver Formation on the northern, western, and north half of the eastern sides of the slurry wall and into the eluvial clay unit of

the alluvium on the southern and south half of the eastern sides of the slurry wall.

- d. Earth fill cover averaging about 32 inches thick over the area surrounded by the slurry wall, with compaction of approximately the bottom 12-inches of fill.
 - e. Final grading for surface water drainage over the earth cover and around the cover perimeter.
 - f. Placement of soil amendments, seed, and material for erosion protection over all surface areas disturbed during construction; with the exception of the service roads and borrow area.
 - g. Six soil moisture monitoring stations both within the area surrounded by the slurry wall and outside of the slurry wall perimeter.
 - h. Abandonment of fifteen alluvial and Denver Formation monitoring wells and ten well points located throughout the construction area.
 - i. Seven new alluvial groundwater monitoring wells outside of the area surrounded by the slurry wall.
 - j. Five pairs of permanent piezometers installed adjacent to the slurry wall.
4. Perform all work required for the construction of the Shell Section 36 Trenches IRA as described more fully in the Shell Section 36 Trenches IRA Implementation Document (as defined below), including the following:

- a. Procure all required materials and subcontractors.
- b. Provide supervisory and construction labor to manage subcontracts; install a slurry wall, earth cover with adequate site drainage, wells, piezometers, soil monitoring stations, and required roads and utilities; and abandon existing wells.
- c. Supervise startup of monitoring and maintenance programs for the Shell Section 36 Trenches upon completion of construction.
- d. Perform all activities described in this paragraph 4 in accordance with the construction work plan, basis of the estimated costs, schedule, technical specifications, engineering drawings, and health and safety plan to be set forth in the Shell Section 36 Trenches IRA Implementation Document.
- e. The term "Shell Section 36 Trenches IRA Implementation Document" means the following documents, both of which are hereby incorporated herein by reference:

- (1) Final Implementation Document for the IRA to implement a system of passive containment and monitoring in the Shell Section 36 Trenches area. This document is to be prepared by Morrison-Knudsen (MK) for Shell and any amendments or modifications thereof and supplements thereto.
- (2) Prior to issuance of the documents described in 4.e.(1), but only prior to issuance of the

documents, the Draft Implementation Document for the IRA to implement a system of passive containment and monitoring in the Shell Section 36 Trenches area shall be prepared by MK for Shell.

5. The Draft Implementation Document must be completed by December 20, 1990. The Army will issue the Draft Implementation Document to the other Organizations, Department of Interior, and the State by December 20, 1990, and require comments within thirty (30) days of the date of issuance. Within five (5) working days after the end of the 30 days comment period, the Army will submit copies of all comments received to Shell for review and inclusion in the Final Implementation Document, as appropriate.

Shell will submit thirty (30) complete copies of the Final Implementation Document to the Army as a deliverable within twenty (20) working days of receipt of comments by Shell on the Draft Implementation Document. The Army shall issue the Final Implementation Document to the other Organizations, Department of Justice, and the State no later than five (5) working days after receipt from Shell.

6. During performance of construction of this Interim Response Action, Shell shall submit a monthly letter progress report to the Army summarizing work performed versus work planned, highlighting major items completed, and updating the schedule of construction until the Interim Response Action is completed. Monthly letter reports shall be submitted to the Army within ten (10) working days after the end of each

month. At the close of the project, a letter will be provided to the Army summarizing the work completed.

IN WITNESS WHEREOF, I have hereunder set my hand as a authorized representative of the United States Department of the Army.

Date 22 FEB 91 Kevin T Blase
(acting) Deputy Program Manager

IN WITNESS WHEREOF, I have hereunder set my hand as an authorized representative of Shell Oil Company.

Date 2/25/91 W J McKeeney
Manager Projects, Denver Site
Project

3.0 CONSTRUCTION WORK PLAN

1. Survey: The construction area will be staked to locate and define the dimensions of cut and fill earthwork, and to locate wells and facilities.
2. Monitoring During Construction: The general nature of subsurface contamination has been characterized from previous investigations in the Shell Trenches area, and is reflected in the protective measures outlined in the Task Specific Health and Safety Plan.

All construction activities described in previous sections will be monitored by Health and Safety Personnel using field instrumentation. Should results of monitoring warrant further investigations, additional testwork will be specified and implemented.

3. Construction: Construction of the slurry wall will be completed using the vibrating beam injection method. Distribution of fill for the earth cover will be accomplished using low ground pressure equipment. Other construction will be performed using conventional methods established for the RMA. Any contaminated groundwater, soils, or other materials that are removed during well/piezometer construction or abandonment will be drummed and handled per RMA Standard Operating Procedures.

The first construction activity will involve abandonment of wells inside the trench area, which will be completed concurrent with placement of the temporary service road to December 7th Avenue and permanent service road to the construction area. Construction of service roads will enable fill material to be hauled and dumped on clean fill in the Shell Trenches area for subsequent spreading. This

technique will also eliminate decontamination requirements for vehicles transporting fill material. During use of the temporary service road, traffic control measures will be implemented at the December 7th Avenue crossing. These measures will include placement of a heavy equipment crossing and stop signs displayed in both directions on December 7th Avenue. Construction of the temporary road will be coordinated with the Army to schedule removal by the Army of above-grade pipe and insulation conflicting with the right-of-way for the temporary service road. The pipe trends west-east from the South Plants to the Hydrazine Blending Facility and is located south of the railroad tracks.

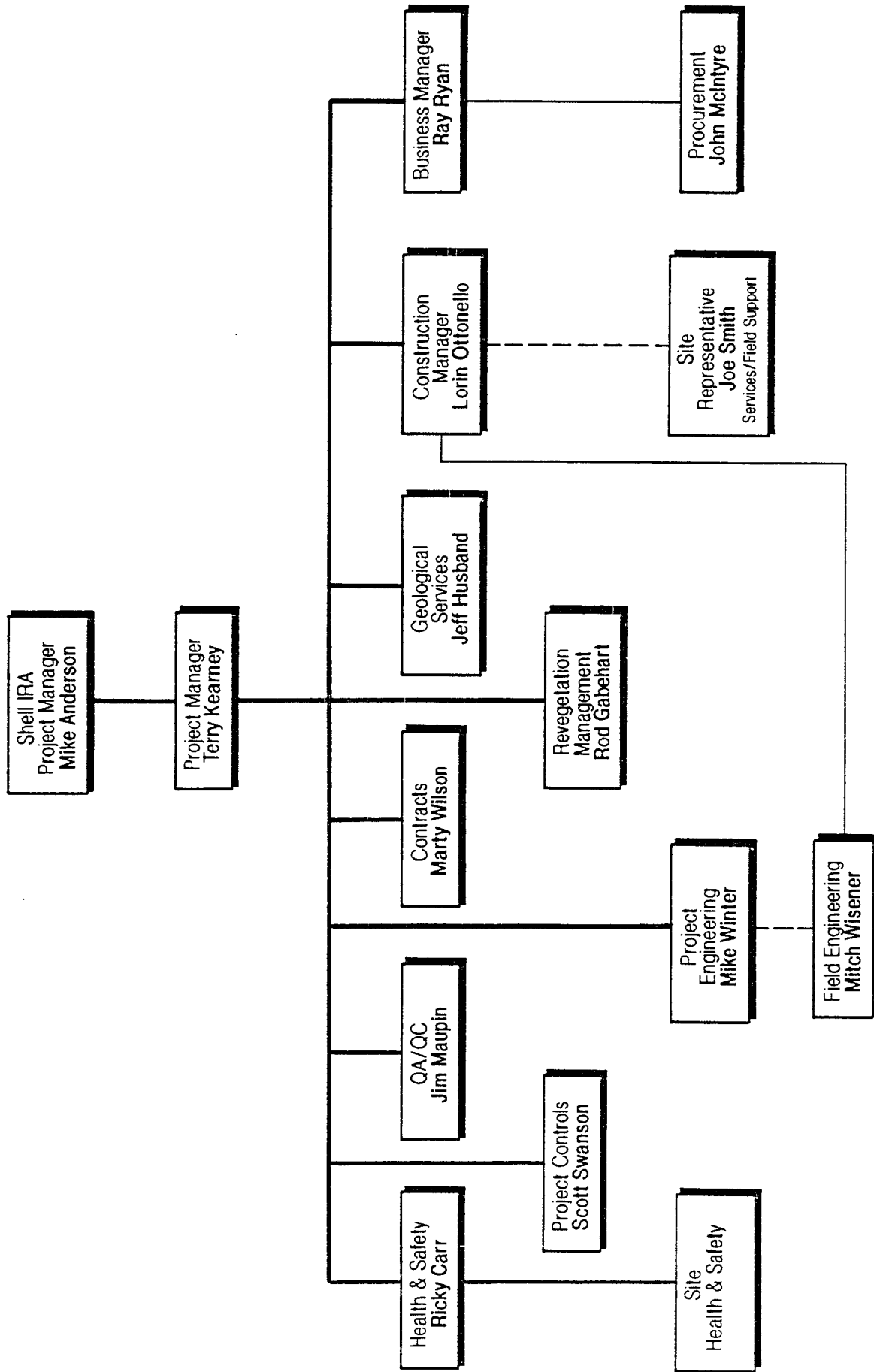
Construction of the compacted layer of the earth cover will focus initially on constructing an elevated working bench along the alignment of the slurry wall. As the slurry wall is placed, portions of the working bench may be regraded to complete placement of the remainder of the compacted layer. Final grading will extend outside of the area surrounded by the slurry wall to enable establishment of adequate site drainage. Abandonment of wells outside the surrounded area and construction of monitoring wells will be done concurrently with slurry wall and cover placement, since the locations are outside the area of earthwork construction. Revegetation work will be completed in all areas disturbed by new construction, with the exception of the service roads and borrow area.

4. Dust Control: During the period when earthwork operations are in progress, a water truck will be onsite. Surfaces will be sprayed to maintain the surface soil moisture content and control the evolution of dust.

5. Geological Services: A geologist will be onsite to monitor the construction work and log information on slurry wall depths and borehole lithology, construction for wells and piezometers, and well abandonment.
6. Revegetation Management: A natural resources specialist will be onsite periodically to supervise soil preparation, seeding, and placement of material for erosion protection; and to evaluate the development of the vegetative cover. This individual will also supervise placement of soil moisture monitoring stations and coordinate with other scientific personnel in the collection and management of data from the monitoring network.
7. Health and Safety: A Health and Safety representative will be onsite to monitor construction activities using field instrumentation to ensure worker's safety and identify the presence of any volatile organic compounds that may be encountered.
8. Quality Assurance/Quality Control (QA/QC): Periodic field surveillance of construction activities will be performed by QA/QC personnel, with audits performed by the project QA/QC management.
9. Reporting: The Construction Manager shall prepare Daily Construction Reports to record field activities. Separately, a daily personnel log shall be used to record the names of all personnel who have visited the site.

As described in the IRA Scope of Work, a summary of IRA construction activities will be presented to the Army on a monthly basis.

10. Organization: An organization chart for the construction of the Shell Section 36 Trenches IRA is attached.



Organization Chart Shell Section 36 Trenches IRA

4.0 ESTIMATED COST AND BASIS OF THE ESTIMATE

The attached Cost Estimate Summary has been prepared for implementation of the Shell Section 36 Trenches IRA. Included in the estimated costs are the slurry wall, earthwork, revegetation, well and piezometer construction, well abandonment, and placement of the soil monitoring network.

All activities are defined in the enclosed engineering specifications (Volume II), and the enclosed drawings (Volume III). The subject specifications and drawings were issued as part of this Draft Implementation Document for review and comment by the Organizations and the State.

Labor costs are based on the prevailing merit shop wage rates in Adams County, Colorado. Equipment hourly rates are based on historical Morrison-Knudsen Corporation equipment operating costs. Prices for permanent materials and major equipment are based on verbal quotations and current estimating manuals.

Indirect costs for construction management, Contractor's overhead and fee, and the Health and Safety Program are also included in the estimate. The estimate has been prepared on the basis of Morrison-Knudsen Corporation acting as construction manager for Shell Oil Company and subcontracting all work, except construction of soil moisture monitoring stations.

For the development of costs for health and safety supplies as well as labor productivity estimates, it was assumed that all work will be performed with modified Level C personnel protection as stated in the Task Specific Health and Safety Plan.

Estimated costs are represented for the first year of monitoring and maintenance following completion of construction. Costs for drumming potentially contaminated materials have been included

for well cuttings, well development, and groundwater sampling only.

COST ESTIMATE SUMMARY

A. Construction

| | | |
|----|---|---------------|
| 1. | Roadwork | \$ 12,000 |
| 2. | Earth Cover/Revegetation and Soil Moisture Monitoring Stations | 432,000 |
| 3. | Slurry Wall | 456,000 |
| 4. | Monitoring Wells, Piezometers, and Well Abandonment | <u>85,000</u> |

SUBTOTAL DIRECTS \$ 985,000

| | | |
|----|--|----------------|
| 5. | Health and Safety | 129,000 |
| 6. | Construction Management | 324,000 |
| 7. | Contingency, Fees, and Distributable Allocation | <u>337,000</u> |

CONSTRUCTION TOTAL \$1,775,000

B. Annual Monitoring/Maintenance
(including data reporting, Health &
Safety, QA/QC, analytical, waste handling)

| | | |
|----|------------------------------|-----------|
| 1. | Groundwater Quality | \$ 30,000 |
| 2. | Vegetation Cover/Water Table | 29,000 |

| ACTIVITY DESCRIPTION | EARLY START | EARLY FINISH | 1991 | | | | | | | | | | | |
|--------------------------------------|-------------|--------------|------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| | | | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
| IMPLEMENTATION DOCUMENT | | | | | | | | | | | | | | |
| FINAL IMPLEMENTATION DOCUMENT | 25JAN91 | 21FEB91 | | | | | | | | | | | | |
| WELL PACKAGE | | | | | | | | | | | | | | |
| PROCURE WELL SUBCONTRACTOR | 11MAR91 | 12APR91 | | | | | | | | | | | | |
| MOBILIZE / HSS TRAINING | 15APR91 | 3MAY91 | | | | | | | | | | | | |
| ABANDON WELLS INSIDE TRENCH AREA | 6MAY91 | 17MAY91 | | | | | | | | | | | | |
| ABANDON WELLS OUTSIDE TRENCH AREA | 20MAY91 | 5JUL91 | | | | | | | | | | | | |
| MONITORING WELLS | 8JUL91 | 19JUL91 | | | | | | | | | | | | |
| PIEZOMETERS | 22JUL91 | 2AUG91 | | | | | | | | | | | | |
| EARTHWORK PACKAGE | | | | | | | | | | | | | | |
| PROCURE EARTHWORK SUBCONTRACTOR | 22FEB91 | 28MAR91 | | | | | | | | | | | | |
| MOBILIZE / HSS TRAINING | 29MAR91 | 9MAY91 | | | | | | | | | | | | |
| TEMPORARY ROAD | 10MAY91 | 16MAY91 | | | | | | | | | | | | |
| COMPACTED LAYER PLACEMENT | 20MAY91 | 21JUN91 | | | | | | | | | | | | |
| TOPSOIL PLACEMENT / FINAL GRADING | 24JUN91 | 9AUG91 | | | | | | | | | | | | |
| SLURRY WALL PACKAGE | | | | | | | | | | | | | | |
| PROCURE SLURRY WALL SUBCONTRACTOR | 18MAR91 | 19APR91 | | | | | | | | | | | | |
| MOBILIZE / HSS TRAINING | 22APR91 | 31MAY91 | | | | | | | | | | | | |
| SLURRY WALL | 3JUN91 | 19JUL91 | | | | | | | | | | | | |
| REVEGETATION PACKAGE | | | | | | | | | | | | | | |
| PROCURE REVEGETATION SUBCONTRACTOR | 10JUN91 | 12JUL91 | | | | | | | | | | | | |
| MOBILIZE / HSS TRAINING | 15JUL91 | 23AUG91 | | | | | | | | | | | | |
| SOIL PREP, SEEDING, MULCHING | 26AUG91 | 20SEP91 | | | | | | | | | | | | |
| MONITORING | | | | | | | | | | | | | | |
| SOIL MONITORING NETWORK INSTALLATION | 23SEP91 | 4OCT91 | | | | | | | | | | | | |

Activity Bar/Early Dates

Critical Activity

Progress Bar

Project Start : 25JAN91

Project Finish: 30DEC91

MK ENVIRONMENTAL SERVICES

SHELL SECTION 36 TRENCHES

DRAFT PRELIMINARY SCHEDULE

Sheet 1 of 1

Data Date: 25JAN91

Plot Date: 11DEC90

Prismavera Systems, Inc. 1994-1999

1.0 INTRODUCTION/SCOPE

This Task-Specific Health and Safety Plan (TSHSP) provides the basis for performing the Shell Section 36 Trenches Interim Response Action in a way that will control and minimize the risk to the health and safety of MK and subcontractor personnel. The plan defines the specific requirements and protocols for the protection of personnel performing the work.

Applicability of the TSHSP extends to all MK employees, subcontractors, and site visitors under MK's control. This work will be performed in accordance with the MK RMA Project Safety and Health Program, the RMA Site Health and Safety Plan, the MK-Ferguson Safety Manual, and all federal occupational health and safety rules and regulations.

This TSHSP will be reviewed by all MK and subcontractor personnel involved with the task prior to performing the work.

2.0 HAZARD ASSESSMENT

2.1 Chemical Hazards

Historical information indicates that the following chemical compounds have been detected in the groundwater and/or soil in the area that the work will be performed.

| <u>Chemical</u> | <u>PEL/TLV</u> |
|--|--|
| Aldrin | 0.25 mg/m ³ (0.017 ppm) |
| Arsenic | 0.2 mg/m ³ TLV 0.5 (PEL-organic) 0.01 (PEL-inorganic) |
| Benzene | 1 ppm |
| Carbon Tetrachloride | 2 ppm |
| Chlordane | 0.5 mg/m ³ (0.030 ppm) |
| Chlorobenzene | 75 ppm |
| Chloroform | 2 ppm |
| p-Chlorophenylmethyl sulfide (CPMS) | Not Established |
| p-Chlorophenylmethyl sulfoxide (CPMSO) | None Established |
| p-Chlorophenylmethyl sulfone (CPMSO ₂) | Not Established |
| Dibromochloropropane (DBCP) | 1 ppb |
| p,p-Dichlorodiphenyltrichloroethylene (DDT) | 1.0 mg/m ³ (0.069 ppm) |
| p,p-Dichlorodiphenyltrichloroethylene (DDE) | (1)Not Established |
| Dicyclopentadiene (DCPD) | 5 ppm |
| 1,2-Dichloroethane | 50 ppm (10 ppm TLV) |
| 1,2-Dichloropropane | --- |
| Dieldrin | 0.25 mg/m ³ (0.016 ppm) |
| Diisopropyl Methyl Phosphonate (DIMP) | Not Established |
| Dimethyldisulfide (DMDS) | (1)Not Established |
| Dimethyl Methyl Phosphonate (DMMP) | None Established |
| Endrin | 0.1 mg/m ³ (0.006 ppm) |

| <u>Chemical</u> | <u>PEL/TLV</u> |
|----------------------------|------------------------------|
| Ethylbenzene | 100 ppm |
| Hexachlorocyclopentadiene | None Established |
| Hexachloroethane | 1 ppm |
| Hexachlorobutadiene | 0.02 ppm |
| Isodrin | None Established |
| Methylene Chloride | 100 ppm |
| Pentachlorobenzene | --- |
| Phenol | 19 mg/m ³ (5 ppm) |
| 1,2,3,4-Tetrachlorobenzene | --- |
| Tetrachloroethylene | 25 ppm |
| Toluene | 100 ppm |
| 1,1,2-Trichloroethane | 10 ppm |
| Trichloroethylene | 50 ppm |
| Xylene | 100 ppm |

(1) Staff toxicologists concur that the compound is not of any health concern unless a concentration of 750ppb is reached.

Aldrin has been recommended by the National Institute for Occupational Safety and Health (NIOSH) to be controlled and handled as a potential human carcinogen. The Occupational Safety and Health Administration (OSHA) has given aldrin a "Skin" notation. This notation refers to the potential contribution to overall exposure by the cutaneous route including the mucous membranes and eyes.

Arsenic (inorganic) is recommended by NIOSH to be controlled and handled as a potential human carcinogen in the workplace. Skin contact can cause burning, itching and a rash. Repeated skin contact can cause thickened skin and/or patchy areas of darkening and loss of pigment.

Benzene is designated as a potential human carcinogen by NIOSH. The American Conference of Governmental Industrial Hygienist (ACGIH) has designated benzene as a suspected human carcinogen. Repeated skin contact can cause redness, blistering, and dry, scaly dermatitis.

Carbon tetrachloride has been evaluated by the International Agency for Research on Cancer (IARC) and concluded that it causes cancer. NIOSH recommended the chemical be regulated as an occupational carcinogen. Prolonged or repeated skin contact with liquid carbon tetrachloride may result in skin irritation. It can be adsorbed through the intact skin of animals and humans in toxic amounts.

Chlordane is considered a carcinogen by IARC. Skin absorption of chlordane is rapid.

Chloroform has been evaluated by IARC and concluded that chloroform causes cancer. NIOSH has also recommended that chloroform be regulated as an occupational carcinogen. Liquid chloroform has a defatting effect on the skin and may produce chronic irritation with drying and cracking.

Dibromochloropropane (DBCP) is considered a potential human carcinogen by OSHA and the National Toxicology Program (NTP). Low-level repeated or prolonged exposure of male workers has been associated with low sperm count, chromosome abnormality, sterility, decreased testicular size, and increased level of follicle stimulation hormone. These effects were not associated with exposure in subsequent years, indicating that they may be reversible following removal from exposure.

DDT is considered a potential human carcinogen by NIOSH. OSHA has given DDT a "Skin" notation, this refers to the potential contribution to overall exposure by the cutaneous route including the mucous membranes and eyes.

1,2-Dichloroethane, also known as Ethylene dichloride, may be a carcinogen in humans since it has been shown to cause stomach, lung, breasts and other types of cancers in animals.

1,2-Dichloropropane is a soil fumigant component. Exposure occurs principally during manufacture or during bulk handling activities. Since it is generally injected into the soil at depths of 15 to 30 cm, airborne concentrations are generally well below 0.5 ppm even when measured in the middle of a fumigated field. The material is considered flammable.

Dieldrin has been recommended by NIOSH to be controlled and handled as a potential human carcinogen. OSHA has given dieldrin a "Skin" notation, this refers to the potential contribution to overall exposure by the cutaneous route including the mucous membranes and eyes. Dermal absorption is substantially increased when dieldrin is dissolved in organic solvents.

Hexachloroethane has been evaluated by IARC, who concluded the chemical causes cancer. No chronic effects have been reported from industrial exposure, although significant absorption through the skin is said to occur. The ACGIH has issued a Notice of Intended Change from their recommended TLV for hexachloroethane of 1 ppm to 10 ppm with a skin notation.

Hexachlorobutadiene is considered to be a suspected human carcinogen by the ACGIH. This chemical will also cause skin irritation upon contact.

Malathion is less toxic to humans than most anticholinesterase agents because it is metabolized in the liver to an inactive form. After skin absorption, sweating and twitching in the area of absorption may occur, usually within fifteen minutes to four hours.

Methylene Chloride as a liquid may cause skin irritation and dermatitis on prolonged exposure. If the liquid is held in contact with the skin, it may cause skin burns. Splashes of the liquid into the eye may cause irritation. Persons with pre-existing skin disorders may be more susceptible to the effects of this agent.

Phenol in concentrated solution is severely irritating to the human eye and causes conjunctival swelling, the cornea becomes white, and loss of vision has occurred in some cases. Solutions of phenol have a marked corrosive action on any tissue on contact; on skin, there is local anesthesia and a white discoloration, and the area may subsequently become gangrenous. Severe dermatitis will result from contact with dilute solutions of phenol.

Tetrachloroethylene has been put on OSHA "Candidate List" of chemical considered for further scientific review regarding its carcinogenicity. The IARC has evaluated the data on this chemical and has concluded that it causes cancer. Exposure of the skin to liquid tetrachloroethylene for 40 minutes resulted in a severe burning sensation within 5 to 10 minutes, which subsided after 1 to 2 hours. The chemical eye irritation level is given by one researcher as 206 to 235 after a 20 to 30 minute exposure.

1,1,2-Trichloroethane appears on the OSHA "Candidate List" of chemicals being considered for further scientific review regarding its carcinogenicity. This chemical has been evaluated by IARC, which concluded that 1,1,2-Trichloroethane causes cancer.

Trichloroethylene is considered a potential human carcinogen by NIOSH. A dermal response to humans has been seen as reddening of the face, neck, back, and shoulders (degreaser's flush) which occurred in chronically exposed workers following the ingestion of alcohol. Repeated immersion of the hands into liquid trichloroethylene has caused paralysis of the fingers. The chemicals eye irritation level is 400 ppm.

2.2 Dense Non-Aqueous Phase Liquid

Historical information indicates that dense non-aqueous phase liquid (DNAPL) may be encountered during installation of the slurry wall. The DNAPL is described as having the color and consistency of spent motor oil. The DNAPL may contain, but is not necessarily limited to, the following chemical compounds:

Volatile Aromatic Organic Compounds

Toluene
m-Xylene
o-/p-Xylene

Volatile Halogenated Organic Compounds

Carbon Tetrachloride
1,2-Dichloropropane
Tetrachloroethene

Organochlorine Pesticides

Aldrin
Dieldrin
Endrin
Isodrin

Semivolatile

Halogenated Organic

Compounds

Hexachloroethane

Hexachlorobutadiene

Hexachlorocyclopentadiene

Pentachlorobenzene

1,2,3,4-Tetrachlorobenzene

Dibromochloropropane

Past air monitoring that was performed when DNAPL was previously encountered measured organic vapor concentrations up to 10 ppm in the breathing zone of personnel involved with the task.

2.3 Physical Hazards

Physical hazards related to this task include personnel working with or in close proximity of heavy equipment, excavations, use of power tools, falling objects, and heat stress. Personnel need to be cognizant that the use of personal protective equipment may reduce dexterity and visibility and increase the difficulty of performing some tasks. Physical hazards may be controlled through the use of equipment guards, work practices, and training. Only equipment that is used for its intended task and that is in safe operating condition will be used. Personnel will be trained in the proper use and safe operation of the tools and equipment they utilize.

Prior to any drilling, all boring sites must be cleared for safety purposes. Geophysical clearance surveys will be used to ensure drilling will not encounter buried unexploded ordnance (UXO) or other metal that could pose a significant safety risk. A metal detector will also be used to check for surficial (0 to 2 ft) metal present.

3.0 TRAINING

All personnel performing fieldwork for this task will have completed the forty (40) hour hazardous waste operations health and safety training pursuant to 29 CFR 1910.120(e) before beginning work. Eight (8) hour annual refresher training is required as necessary. The MK Construction Manager and subcontractor supervisors are required to have completed eight (8) hour Hazardous Waste Operations Supervisor/Manager training prior to the beginning of fieldwork.

Task/site specific training regarding the following topics will be given to all personnel performing fieldwork:

- Name of Site Safety and Health Supervisor and alternate.
- Safety and Health hazards related to this task.
- PPE requirements.
- Work practices.
- Hazard control.

- Medical surveillance requirements, including recognition of signs and symptoms which might indicate overexposure to chemical hazards.
- Decontamination procedures.
- Emergency response.

4.0 MEDICAL SURVEILLANCE

The basic requirements of the RMA Project Medical Surveillance Program shall apply to implementation of this task. No additional medical surveillance requirements are necessary.

5.0 PERSONAL PROTECTIVE EQUIPMENT (PPE)

The PPE to be utilized during the Shell Section 36 Trenches IRA is dependent upon the specific task to be performed, the potential for contacting potentially contaminated soils or groundwater, and the concentration of air contaminants in the breathing zone of project personnel. The following PPE will be utilized (modified, as necessary, by the level of air contaminants measured in the breathing zone or at the discretion of the Site Health and Safety Officer).

| <u>Task</u> | <u>PPE Level</u> |
|---|------------------|
| Temporary Service Road | D |
| Permanent Service Road (excluding truck drivers) | Modified C |
| Slurry Wall | Modified C |
| Earth Fill Cover | Modified C |
| Final Grading | Modified C |
| Revegetation | Modified C |
| Soil Moisture Monitoring Stations | Modified C |
| Well Abandonment | Modified C |
| New Monitoring Wells/Piezometers | Modified C |

5.1 Level D Personal Protective Equipment:

- PVC/Polyurethane steel-toed boots (except personnel conducting geophysical clearance surveys)
- Cotton Coveralls
- Hard hats
- Safety glasses with side shields
- Gloves

5.2 Level C Modified Personal Protective Equipment:

- PVC/Polyurethane steel-toed boots (except personnel conducting geophysical clearance surveys)
- Cotton Coveralls (inner)
- Polyethylene coated Tyvek coveralls (outer; personnel involved in drilling or slurry wall construction will use polycoated Tyvek over coveralls with PVC splash suits)
- Hard hats
- Safety glasses with side shields
- Vinyl gloves (inner; personnel involved in drilling or slurry wall construction will use Viton)
- Nitrile gloves (outer; personnel involved in drilling or slurry wall construction will use butyl rubber). Leather gloves may be worn outside of the nitrile gloves, but must remain on site at all times and be disposed of with other disposable clothing at the conclusion of the task.

5.3 Level C Personal Protective Equipment:

- PVC/Polyurethane steel-toed boots (except personnel conducting geophysical clearance surveys)
- Cotton Coveralls (inner)
- Polyethylene coated Tyvek coveralls (outer; personnel involved in drilling or slurry wall construction will use polycoated Tyvek over coveralls with PVC splash suits)
- Hard hats
- Vinyl gloves (inner; personnel involved in drilling or slurry wall construction will use Viton)
- Nitrile gloves (outer; personnel involved in drilling or slurry wall construction will use butyl rubber). Leather gloves may be worn outside of the nitrile gloves, but must remain on site at all times and be disposed of with other disposable clothing at the conclusion of the task.
- Full-face air-purifying respirator with GMC-H cartridges (or equivalent).

6.0 SAMPLING/MONITORING

Sampling/monitoring will be performed to assess the exposure of personnel to hazardous materials and substances and to ensure that the proper level of personal protective equipment has been selected. Monitoring will also be conducted to delineate areas where protection is needed.

Air monitoring will be performed using direct-reading real-time instruments. Direct-reading instruments will be calibrated daily before use according to the manufacturer's instructions. The following table describes the appropriate response action for the detection of organic vapors. A flame-ionization detector (Foxboro Century OVA-128 or equivalent) will be used to monitor organic vapors. Monitoring will be performed periodically, as necessary.

Concentration in Breathing Zone*

Required Response

Less than 1 ppm

- 1) Level D or Modified Level C PPE.
- 2) Continue monitoring, as necessary.

Greater than 1 ppm,
Less than 20 ppm

- 1) Upgrade to Level C PPE
- 2) Increase frequency of monitoring.
- 3) Determine extent of airborne levels, modify extent of exclusion zones as necessary.

Greater than 20 ppm

- 1) Cease disturbing contaminated material, evacuate area.
- 2) Notify Construction Mgr. and H&S Mgr.
- 3) Determine extent of airborne levels, modify extent of exclusion zones as necessary.

* For five consecutive minutes; these levels are concentrations above background.

Air sampling using NIOSH or OSHA methodology will be performed at the discretion of the Site Health and Safety Officer.

7.0 SITE CONTROL

An exclusion zone will be established for each task where Level C-Modified PPE (or greater) is required. Entry into the exclusion zone is restricted to those personnel wearing the appropriate personal protective equipment. For the tasks involving drilling, the exclusion zone will be a minimum of 25 feet in all directions around the drill rig. The exclusion zone will be conspicuously demarcated through the use of orange traffic cones, or other equally suitable means. The Site Health and Safety Officer has at his/her discretion the authority to increase the size of the exclusion zone, if necessary, or to establish an exclusion zone for any of the other tasks.

IMPLEMENTATION DOCUMENT
FOR OTHER CONTAMINATION SOURCES
INTERIM RESPONSE ACTION
SHELL SECTION 36 TRENCHES, RMA

VOLUME 2 ENGINEERING SPECIFICATIONS

FINAL

March 1991

Prepared by
Morrison-Knudsen Corporation
Environmental Services Group
Denver, Colorado 80203

Prepared for
Shell Oil Company
Denver, Colorado 80203

SPECIFICATION LIST

| <u>Specification</u> | <u>Description</u> |
|----------------------|--|
| 1. 34-0212 | Site Preparation, Grading, Excavating, and Backfilling |
| 2. 34-0229 | Soil Preparation, Seeding, and Mulching |
| 3. 34-0261 | Soil Moisture Monitoring Stations |
| 4. 34-0263 | Slurry Cutoff Wall-Vibrating Beam Injection Method |
| 5. 34-0272 | Alluvial Groundwater Monitoring Wells |
| 6. 34-0274 | Well Abandonment |
| 7. 34-0276 | Permanent Piezometers |
| 8. 34-0301 | Cast-In-Place Concrete |



SPECIFICATION 34-0212

SITE PREPARATION, GRADING, EXCAVATING, AND BACKFILLING

CLIENT: SHELL OIL COMPANY

PROJECT: ROCKY MOUNTAIN ARSENAL REMEDIATION PROJECT

INTERIM RESPONSE ACTION FINAL DETAILED DESIGN

SHELL SECTION 36 TRENCHES IRA

LOCATION: ROCKY MOUNTAIN ARSENAL, COMMERCE CITY, CO

CONTENTSPAGE

| | | |
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| 2. | RELATED WORK | 3 |
| 3. | REFERENCE STANDARDS | 4 |
| 4. | GENERAL PROCEDURES | 4 |
| 5. | SITE PREPARATION | 5 |
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| 8. | MATERIAL STORAGE AND DISPOSAL | 6 |
| 9. | FILLING, BACKFILLING, AND COMPACTING | 6 |
| 10. | GRADING | 8 |
| 11. | INSPECTION | 9 |
| 12. | INCIDENTAL ITEMS | 9 |



SPECIFICATION 34-0212

SITE PREPARATION, GRADING, EXCAVATING, AND BACKFILLING

1. SCOPE

- A. This specification and other Contract Documents cover the furnishing of all equipment, labor, materials, and performance of work for site preparation, excavating, filling, backfilling, grading, and incidental items associated with earthwork as required by applicable drawings and as specified herein.
- B. Generally, required items of work include:
 - 1) Cutting
 - 2) Excavations
 - 3) Filling, backfilling, and compacting
 - 4) Grading of site
 - 5) Incidental items

2. RELATED WORK

- A. The following related work is covered in other specifications:
 - 1) Slurry Cutoff Wall - Vibrating Beam Injection Method (Specification 34-0263)
 - 2) Cast-in-Place Concrete (Specification 34-0301)
 - 3) Soil Preparation, Seeding, and Mulching (Specification 34-0229)
 - 4) Alluvial Monitoring Wells (Specification 34-0272)
 - 5) Permanent Piezometers (Specification 34-0276)



3. REFERENCE STANDARDS

A. Organizations whose standards are referenced herein are as follows:

- 1) AASHTO - American Association of State Highway and Transportation Officials
- 2) ANSI - American National Standards Institute
- 3) ASTM - American Society for Testing and Materials
- 4) ATF - Alcohol, Tobacco and Firearms Division of the U.S. Department of the Treasury
- 5) UBC - Uniform Building Code
- 6) Health and Safety Standard Operating Procedures
- 7) Colorado Standard Specification for Road and Bridge Construction
- 8) OSHA - Occupational Safety and Health Administration

B. Any reference to standards of any society, institute, association or governmental agency shall be the edition in effect as of the date of this specification, unless stated otherwise.

4. GENERAL PROCEDURES

A. Reference Points: Carefully maintain bench marks, monuments, and other reference points. Replace them as the Engineer directs if they are disturbed or destroyed.

B. Engineer: The Engineer will determine by observation and testing the quality of work and materials during earthwork operations. The Engineer will judge: adequacy of site preparation, excavating, suitability of bearing at excavated levels, acceptability of available fill material, and the correct placement and compaction of fill and backfill to specified densities. The Engineer will determine the frequency of testing. Cutting, excavating, filling, backfilling and compacting procedures require the approval of the Engineer as they are successively performed. Any work found unsatisfactory shall be corrected at the Contractor's expense in an approved manner.

C. Portions of the site may contain potentially contaminated materials (hazardous waste). In areas where contaminants are present or discovered,



special procedures as specified by the Engineer shall be followed to protect personnel and avoid further contamination of the site or equipment.

- D. Excavation, removal, disposal or stockpiling of contaminated materials shall conform to the requirements of the construction work plan and be approved by the Engineer. Contaminated soils will be designated by the Engineer. Potentially contaminated or contaminated soils will be stored as directed by the Engineer. If any contaminated or potentially contaminated soils must be removed from the site, they will be drummed by the Contractor in drums provided by the Engineer. The Engineer will be responsible for arranging for characterization, storage, and final disposal of drummed soils, as required.

5. SITE PREPARATION

- A. Cutting: Perform cutting to required lines and grades as shown on the drawings or as indicated by the Engineer. Where unsuitable material is exposed at completion of planned cutting, overexcavate as directed by the Engineer until suitable bearing is reached. If materials are removed below required elevations, through Contractor error or careless cutting, the Engineer will determine corrective measures to be made at the Contractor's expense.

6. EXCAVATING FOR STRUCTURES

- A. Dimensions: Excavate to required elevations and dimensions, allowing ample space for form and material placement, inspection, and form removal. If the nature of the soil permits and the Engineer gives prior approval, excavation may be used as a concrete form. Degree of slope for open cut earth banks shall not exceed safe angle of repose of the soil in either dry or wet condition.
- B. Removing Materials: Excavate all materials encountered, except for existing services and permanent structures. Remove rock, boulders, portions of abandoned structures and other hard obstructions to at least 6" below planned excavation level. Soil conditions at the bottom of excavation shall be subject to the Engineer's approval. Surfaces shall be clean and clear of mud or frozen material, and shall be maintained in good condition until concrete is placed.
- C. Suitable Bearing: Where unsuitable material is exposed at completion of planned excavation, overexcavate as directed by the Engineer until suitable bearing is reached. Place and compact fill as specified herein to correct elevations.
- D. Overexcavation: If materials are removed below required elevations, the Engineer will determine necessary corrective measures to be made at the Contractor's expense.



E. Rock Excavation:

- 1) Rock is defined as lithified material over 1/2 cu.yd in volume or over 3'-0" in greatest dimension, which requires special equipment/procedures to remove.
- 2) It is assumed that materials at the job site can be excavated by hand labor or with normal equipment such as a power shovel or bulldozer. If rock is encountered, notify the Engineer for determination of excavation method before proceeding with further excavating.

7. EXISTING UTILITIES

- A. Locations of existing utilities shown on the drawings are approximate. It shall be the Contractor's responsibility to field verify actual locations. Carefully uncover underground utilities, and support and protect all existing utilities. Do not cut, remove or damage these items without the Engineer's prior written approval; otherwise repair or replace them to the Engineer's satisfaction. Remove abandoned utilities as directed by the Engineer.

8. MATERIAL STORAGE AND DISPOSAL

- A. Select excavated materials which can be reused later; classify and stockpile each separately. Dispose of unsuitable and excess material and debris onsite as directed by the Engineer.

9. FILLING, BACKFILLING, AND COMPACTING

- A. Fill and Backfill Materials: Use Engineer-approved materials obtained from stockpiles of excavated material. Provide fill suitable for required compaction and free of: debris, organic material, rocks and soil clods over 6" diameter where encountered, frozen matter, and excessive moisture or dryness.
- 1) Backfill over Pipes and Utilities: Use uncontaminated material which is free from rocks or debris within 12" of pipes and utilities.
 - 2) All Other Fill and Backfill: Use uncontaminated material which shall not contain rocks over 6" in size.
 - 3) Cover Coat Aggregate: Aggregate will be used for permanent service road. See Section 703.05 Type 1 of Colorado Standard Specifications for Road and Bridge Construction.



B. Placing Fill and Backfill:

- 1) Backfill excavations when installations have been completed, inspected, and approved. Before proceeding, excavations shall be free of forms, debris, and other foreign materials.
- 2) Deposit fill and backfill materials in horizontal layers of maximum 8" loose depth. Place fill using a DGD-LGP vehicle with 36" wide track; or Engineer-approved equal. Compact each 8" layer over the portion of the earth cover designated as compacted and where new service roads and utilities are located; as shown on the drawings. The Engineer may alter maximum depth of layer if, because of equipment, material, or other conditions, it is deemed necessary to assure required degree of compaction. Do not place materials in water or on frozen subgrade. Avoid damage to installed work. Take special care to prevent wedging action or eccentric loading on structures.

C. Maximum Dry Density and Optimum Moisture Content:

- 1) For cohesive soils, maximum dry density and optimum moisture content shall be determined by one of the methods described in ASTM D-698, commonly known as the "Standard Proctor Test."
- 2) For cohesionless soils, relative density shall be determined by the methods described in ASTM D4253 and D4254.

D. Moisture Control: At the time of compacting areas where relatively high density is required, fill material and the surface on which it is to be placed shall be within a range of 0% to 4% above the optimum moisture content. Do not compact fill material until it has attained the required moisture content. Add an accurately determined and carefully measured amount of water to materials or surfaces which are too dry. Pile or spread out to dry, material which is too wet; if necessary, disk, harrow, or pulverize fill material.

E. Compacting:

- 1) General: Furnish satisfactory power-operated or power-driven hand operated equipment wherever possible to compact fill and backfill to requirements specified herein. A footed roller shall be used to compact fill placed in the cover layer designated as compacted on the drawings. If the fill or degree of compaction is unsatisfactory, make necessary adjustments until specifications are met. Material placed over layers not satisfactorily compacted shall be removed and the unsatisfactory areas recompacted.



- 2) Density for Cohesive Soils: For soils having 10% or more, by weight, of particles passing a No. 200 sieve, minimum required compaction densities at optimum moisture content and expressed as percentage of maximum dry density as measured by the Standard Proctor Test, shall be as follows:
- a) Over Pipes and Utilities: 80% (where pipes and utilities are located under slabs, pads, foundations, railroads, and paved areas, 95% compaction density shall be provided)
 - b) Compacted Layer Within Cover: 90%, or that reasonably achieved as approved by the Engineer.
 - c) Topsoil Layer Within Cover: That achieved by placement of fill.
 - d) Compacted Fill for Service Roads and Other Filled Areas: 90%
 - e) Waste Stockpile: None
 - f) Topsoil Stockpile: None
- 3) Density for Cohesionless Soils: For soils having less than 10% by weight, of particles passing a No. 200 sieve, minimum relative density shall be as follows:
- a) Under Paved Areas and Base Course: 70%
 - b) All Other Filled Areas: 70%
 - c) Waste Stockpile: None
 - d) Topsoil Stockpile: None

10. GRADING

- A. General: Perform necessary grading to achieve final elevations closely approximating those required by the drawings. Surfaces shall be reasonably smooth and free from irregularities, with uniform transitions made to adjacent areas. At completion and before acceptance of this work, clear away all equipment, barricades, surplus materials and rubbish. Survey stakes located within the area enclosed by the slurry wall should be removed. Regrade all disturbed areas to approximate natural grade or as directed by the Engineer. Leave the site in a neat, clean, and presentable condition ready to accept seeding and mulching.



- B. Ditches and Swales: Finish grading to readily drain surface water. Take measures to prevent erosion of freshly graded areas by appropriate means until permanent drainage and erosion control facilities are installed. Repair and re-establish areas of settlement or erosion to required elevations and slopes prior to acceptance of the work.
- C. Subgrades and Finish Grade: Form correct grades, crowns, cross-sections, and slopes required by drawings within a tolerance of ± 0.1 ft. Fill and level depressions which might retain water and interfere with surface water drainage.

11. INSPECTION

- A. All materials and each part or detail of the work shall be subject to inspection by the Engineer. The Engineer shall be provided access to all parts of the work and shall be furnished with such information and assistance by the Contractor as is required to make a complete and detailed inspection.
- B. The Engineer may direct the Contractor to remove or uncover portions of the work. After examination, the Contractor shall restore said portions of the work to the standard required by these specifications.
- C. The Contractor shall not proceed until the lines, grades and/or structure locations have been established. Any work performed by the Contractor contrary to the drawings, specifications or instructions of the Engineer, beyond the lines and grades shown on the drawings or any extra work done without authorization of the Engineer, may be ordered removed or replaced at the Contractor's expense.

12. INCIDENTAL ITEMS

- A. Safeguards: Provide, erect, maintain, and later remove temporary safeguards such as barricades, guardrails and fences, signs, lights and flares for protection of personnel, the public, equipment and materials as the Engineer directs and as required by the RMA Facilities Engineer.
- B. Retaining Excavations: Provide shoring, sheeting, and bracing necessary to retain excavations, maintain banks securely, withstand water pressure, prevent cave-ins, and protect life and property. As backfilling proceeds, remove shoring, sheeting and bracing in a manner to prevent damage or disturbance to the construction and surrounding areas.
- C. Water Removal: Maintain grades to promote surface water drainage. Provide and operate equipment to keep construction areas free of subsurface, surface, and storm water. Provide necessary diversion ditches or other Engineer approved facilities for removing water. Dispose of water as directed



by the Engineer so construction and storage areas, streets, roads, and other surfaces are not flooded.

- D. Temporary Working Bench: Contractor shall construct a temporary working bench, slurry mixing area, and equipment assembly pad to allow construction of the slurry wall. Regrading of subgrade shall be done prior to placement of topsoil layer and the remaining compacted layer, as directed by the Engineer.
- E. Temporary Service Road: Contractor shall construct a temporary service road as shown on the drawings to allow transport of fill material from the stockpile to the fill area. Portions of above-grade piping and insulation which lie in the right-of-way of the service road will be removed by the Army. Use of the road will be discontinued upon written notification from the Engineer.
- F. Permanent Service Road: Contractor shall construct a permanent service road as shown on the drawings to allow access to the site from December 7th Avenue.



SPECIFICATION 34-0229

SOIL PREPARATION, SEEDING, AND MULCHING

CLIENT: SHELL OIL COMPANY

PROJECT: ROCKY MOUNTAIN ARSENAL REMEDIATION PROJECT

INTERIM RESPONSE ACTION FINAL DETAILED DESIGN

SHELL SECTION 36 TRENCHES IRA

LOCATION: ROCKY MOUNTAIN ARSENAL, COMMERCE CITY, CO

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SPECIFICATION 34-0229

SOIL PREPARATION, SEEDING, AND MULCHING

1. SCOPE

- A. This specification and other Contract Documents cover the establishment and maintenance of vegetation over the final graded surface.
- B. Generally, the items of work include furnishing materials and completing preparation of the seedbed, seeding, establishment of erosion protection, and monitoring and maintenance of the vegetated cover.

2. RELATED WORK

- A. The following related work is covered in other specifications:
 - 1) Site Preparation, Grading, Excavating, and Backfilling (Specification 34-0212)

3. REFERENCE STANDARDS

- A. Any reference to standards of any society, institute, association or governmental agency shall be the edition in effect as of the date of this specification, unless stated otherwise.

4. GENERAL PROCEDURES

- A. Reference Points: Carefully maintain bench marks, monuments, and other reference points. Replace them as the Engineer directs if they are disturbed or destroyed.
- B. Engineer/Contractor: Seedbed preparation, seeding, and establishment of erosion protection shall be completed by a qualified Contractor. The Contractor shall have experience with the type of work to be performed. The Engineer will supervise all work performed by the Contractor, and will implement and supervise monitoring activities and maintenance of the vegetated cover. The Engineer will be knowledgeable in performing and supervising the type of work specified herein. The work described above shall be completed to the satisfaction of the Engineer. The Engineer will determine the quality of work by observation and, if desired, testing.



- C. Contaminated Materials: It is anticipated that soil preparation, seeding, and mulching will be completed in filled or uncontaminated cut areas. In areas where contaminants are discovered through Health and Safety monitoring, special procedures as specified by the Engineer shall be followed to protect personnel and avoid further contamination of the site or equipment.

5. SEEDBED PREPARATION

- A. Disking: Disk soil to a depth of 6-8 inches to loosen and aerate the soil. The Engineer will approve the type of equipment to be used and whether one or two passes over the ground surface will be required, depending upon the type of equipment and the topsoil compaction resulting from final site grading.
- B. Soil Amendments/Fertilizer: Following completion of disking, apply amendments to the soil at the following rates:
- 1) Nitrogen - 35 lbs/acre
 - 2) Phosphorus - 35 lbs/acre
 - 3) Incorporate commercial fertilizer into the upper 2-3 inches of soil using a spiked tooth harrow. The commercial brand and rate of application of the fertilizer shall be approved in advance by the Engineer.

The Engineer will approve the type of equipment and method to be used for applying and mixing in amendments.

6. SEEDING

- A. Seed Specie: Crested Wheatgrass; Hycrest variety.
- B. Application Rate: 20 lbs/acre
- C. Seeding Depth: 1/2 - 3/4 inch
- D. Schedule: The preferred time period for seeding is October/November. However, seed may be applied in mid-September to allow sufficient time for seed germination and vegetation establishment before first frost.
- E. Method: The equipment and method used to seed will be approved by the Engineer.



7. EROSION PROTECTION

- A. Mulching: Following seeding, complete mulching to minimize the potential for soil erosion. Mulch shall be free of mold, mildew, and weed seeds.
- 1) Mulch Type - Grass Hay
 - 2) Application Rate - 2 tons/acre
 - 3) Stem Length - Minimum of 4-6 inches (prior to crimping)
 - 4) Method - Crimping (The equipment used will be approved by the Engineer)
- B. Water Bars: Water bars may be constructed, as necessary, to shorten the lengths of slopes having sufficient slope length and grade to readily erode. Following completion of final site grading, the Engineer will determine whether water bars will be constructed, and the number and location of bars.

8. MONITORING/MAINTENANCE

- A. Maintenance: Following placement of erosion protection, the following activities that may be required at the discretion of and under the supervision of the Engineer are:
- 1) Regrade portions of the topsoil layer, if and where significant erosion has occurred.
 - 2) Inter-seed to maintain acceptable plant density. The seed mixture and seeding schedule will be approved by the Engineer.
- B. Monitoring: Soil moisture monitoring stations shall be installed at several locations as shown on the drawings. The frequency of moisture measurements and the method of collecting and reporting data will be determined by the Engineer.



MORRISON KNUDSEN CORPORATION

ENVIRONMENTAL SERVICES GROUP

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SPECIFICATION 34-0261

SOIL MOISTURE MONITORING STATIONS

CLIENT: SHELL OIL COMPANY

PROJECT: ROCKY MOUNTAIN ARSENAL REMEDIATION PROJECT

INTERIM RESPONSE ACTION FINAL DETAILED DESIGN

SHELL SECTION 36 TRENCHES IRA

LOCATION: ROCKY MOUNTAIN ARSENAL, COMMERCE CITY, CO



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SPECIFICATION 34-0261

SOIL MOISTURE MONITORING STATIONS

1. SCOPE

- A. This specification and other Contract Documents cover installation and maintenance of soil moisture monitoring stations.
- B. Generally, the items of work include installing five soil moisture monitoring stations by augering boreholes, placing soil moisture wafers, backfilling, and compacting.

2. RELATED WORK

- A. The following related work is covered in other specifications:
 - 1) Soil preparation, Seeding, and Mulching (Specification 34-0229).
 - 2) Site Preparation, Grading, Excavating, and Backfilling (Specification 34-0212).

3. REFERENCE STANDARDS

- A. Any reference to standards of any society, institute, association or governmental agency shall be the edition in effect as of the date of this specification, unless stated otherwise.

4. GENERAL PROCEDURES

- A. Reference Points: Carefully maintain bench marks, monuments, and other reference points. Replace them as the Engineer directs if they are disturbed or destroyed.
- B. Engineer/Contractor: Installation of soil moisture monitoring stations shall be completed by qualified personnel. The Engineer will supervise all work performed, and will implement and supervise monitoring and maintenance activities. The Engineer will be knowledgeable in performing and supervising the type of work specified herein. The work described shall be completed to the satisfaction of the Engineer. The Engineer will determine the quality of work by observation and testing.



- C. Contaminated Materials: It is anticipated that installation of soil moisture monitoring stations will be completed in filled or uncontaminated areas. In areas where contaminants are discovered, special procedures as specified by the Engineer shall be followed to protect personnel and avoid further contamination of the site or equipment.

5. SOIL MOISTURE MONITORING STATION INSTALLATION

- A. Excavation: Five boreholes will be augured to a depth of approximately 2'-6". Soil material removed during augering will be retained and used to backfill as soil moisture wafers are placed in the borehole.
- B. Soil Moisture Wafer Placement: A total of five soil moisture wafers will be placed in each augured hole. Wafers will be placed at five depths below the surface, as shown on the drawings. After placement of each wafer, the borehole will be backfilled with augured cuttings and compacted to approximately the same as surrounding soil. Successive wafers will then be placed, each followed by additional backfilling and compacting, until all wafers have been placed at the proper depths. Care must be taken to insure that all electrical wire leads extend out of the soil surface a sufficient amount to allow for connection to a data collection device.

6. DATA COLLECTION

- A. The frequency of soil moisture measurements and the method of collecting and reporting data will be determined by the Engineer.



SPECIFICATION 34-0263

SLURRY CUTOFF WALL - VIBRATING BEAM INJECTION METHOD

CLIENT: SHELL OIL COMPANY

PROJECT: ROCKY MOUNTAIN ARSENAL REMEDIATION PROJECT

INTERIM RESPONSE ACTION FINAL DETAILED DESIGN

SHELL SECTION 36 TRENCHES IRA

LOCATION: ROCKY MOUNTAIN ARSENAL, COMMERCE CITY, CO



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SPECIFICATION 34-0263

SLURRY CUTOFF WALL - VIBRATING BEAM INJECTION METHOD

1. SCOPE

- A. This specification contains the requirements for the slurry cutoff wall using the vibrating beam injection method, as hereinafter specified or as required to properly complete the work. The vibrating beam injection method of slurry cutoff wall construction utilizes a crane with a special suspended I-beam connected to a large capacity vibrator. The vibrator enables the I-beam to penetrate the subsurface to the planned depth. Although a vibrating beam is most commonly used to insert the beam, a non-vibrating driver may be used upon advance approval by the Engineer. The slurry is to be injected at the base of the I-beam to create a minimum four-inch-thick continuous flexible slurry wall panel. The continuous slurry wall is created by overlapping panels.
- B. The work consists of furnishing plant, labor, equipment and materials and of performing operations as required to construct the slurry cutoff wall as specified on drawings and in this specification. The slurry cutoff wall shall be constructed to the lines, grades, and cross sections as indicated on the drawings. The wall shall be essentially vertical, shall be composed of an approved slurry mixture pumped under controlled pressure to fill an area penetrating the underlying strata; and shall be keyed into the appropriate underlying low permeability stratum as indicated on the drawings.

2. RELATED WORK

- A. The following related work is covered in other specifications:
 - 1) Site Preparation, Grading, Excavating and Backfilling (Specification 34-0212)

3. REFERENCE STANDARDS

- A. Organizations whose standards are referenced herein are as follows:
 - 1) API - American Petroleum Institute
 - 2) ASTM - American Society for Testing and Materials



4. CONTRACTOR QUALIFICATIONS

- A. Experience: The Contractor will be required to submit documentation of work experience showing competence in slurry wall construction with the vibrating beam injection method. Such documentation must show that the slurry wall Contractor has a minimum of three years experience in vibrated beam slurry wall construction, and has participated in the construction of not less than five projects of similar scope. The Contractor will also be required to submit evidence that competent personnel are available to carry out the operations specified, and such personnel will have previous experience in the vibrating beam injection method of slurry cutoff wall construction.
- B. Slurry Wall Specialist: A construction and slurry wall specialist(s) (as approved by the Engineer) having experience with the vibrating beam method of slurry cutoff wall construction shall be used to supervise construction, slurry preparation, and quality control. The specialist(s) shall be at the site of operations at all times that the installation is in process. The knowledge and experience of the specialist(s) should include, but not necessarily be limited to: 1) mixing methods required to properly mix the slurry required; and 2) construction equipment and materials testing as required for slurry cutoff wall construction using the vibrating beam injection method. The specialist(s) shall control the mixing, composition, placement, cleaning, and maintenance of the slurry. The credentials of the specialist(s) shall be submitted to the Engineer for approval three (3) weeks prior to starting slurry wall construction.

5. GEOTECHNICAL SITE CONDITIONS

- A. Exploratory Borings: Boreholes have been drilled by the Engineer to determine the depth to bedrock and the character of alluvial materials overlying the bedrock. A general lithologic log is shown on Drawing 37803-34-003. Cone penetrometer borings have also been made over the site. The Engineer assumes no responsibility for interpretation or deductions made by the Contractor from any of the logs or borings. Local variations in the subsurface strata are to be expected. The logs are available for inspection from the office of MK-Environmental Services located in Denver, Colorado.
- B. Subsurface Conditions: Borehole information, available from the Engineer, indicates that the material up to 10 feet below ground surface is moderately well-sorted, fine-grained, unconsolidated sand interpreted to be eolian in origin. This eolian sand unit is underlain by approximately 8 to 15 feet of silty clay interpreted to be eluvial in origin. Underlying the eluvial clay unit is the Denver Formation which is composed of siltstones and claystones. The depth to bedrock along the proposed slurry wall is estimated to range from approximately 19 to 26 feet below existing ground surface. The top few feet of the upper Denver Formation is typically weathered. As shown on the drawings and discussed in Section 9 of these Specifications, approximately the



southern and south half of the eastern walls of the slurry cutoff wall are to be keyed into the eluvial clay unit, and the remaining portion of the wall is to be keyed into the upper Denver Formation. Estimates of the compressive strength of the eluvial clay unit and weathered Denver Formation may be obtained from the Engineer.

- C. Groundwater: The water table measured during August 1990 is shown on the drawings that illustrate the profiles of the proposed slurry wall. The eluvial clay unit forms a low permeability layer underlying the eolian sand unit. In core samples, the clay is moist, but may not be saturated.
- D. Geophysical Screening: A geophysical screening program was conducted to determine a location for the slurry cutoff wall that would minimize the chance of encountering unexploded ordnance or other subsurface obstructions during construction. A report of the investigation is available for inspection at the offices of MK-Environmental Services in Denver, Colorado.

6. SUBMITTALS

- A. General: The Contractor shall provide the submittals outlined herein to the Engineer at least three (3) weeks prior to the start of construction for approval.
- B. Schedule and Sequence of Operations: A schedule and sequence of operations including, but not necessarily limited to: 1) slurry cutoff wall construction; 2) waste management; 3) slurry preparation; and 4) clean-up.
- C. Layout of Operations: A layout of operations including, but not necessarily limited to, drawings depicting: 1) IMPERMIX storage area(s); 2) slurry preparation area(s); 3) hydration area(s); 4) location and sizes of stationary equipment; 5) water storage tanks, pumps, valves, lines, hoses and materials; 6) waste areas; and 7) equipment assembly areas. Operations and storage of materials within the area to be enclosed by the slurry wall (outlined on the drawings) will not be allowed.
- D. Slurry Cutoff Wall Construction Method and Equipment: A description of the proposed construction method of the slurry cutoff wall and a listing of the Contractor's available equipment.
- E. Material Certification: Written certification showing that the material used to make the grout meets the requirements of Section 7 of these specifications. If needed, the Contractor shall also submit a written statement as to the need for any additional admixtures, and/or retarders, and their effect on the slurry mixture.



- F. Slurry Mix Design: The design of the IMPERMIX grouting mix, which shall meet all requirements of the IMPERMIX manufacturer.
- G. Quality Control Testing Equipment and Procedures: Methodology proposed to perform required quality control tests.

7. MATERIALS

- A. Slurry: The slurry shall consist of a stable colloidal suspension of IMPERMIX (as sold by Envirotrench Company, Pelham, New York or Engineer approved equal), and water. IMPERMIX is a self-hardening slurry that is mechanically viscified.
- B. Slurry Properties: At the time of injection, slurry shall meet the following requirements:
 - 1) Viscosity of at least 36 marsh cone seconds as determined in accordance with API RP-13B.
 - 2) Minimum slurry mixture temperature shall be forty (40) degrees Fahrenheit.
 - 3) After proper agitation, the resulting IMPERMIX slurry shall be homogeneous prior to use, except that up to three percent (3%) free water shall be allowed.
 - 4) The water loss shall be tested in accordance with "Low Temperature Filtration Test" API RP-13B.
 - 5) The mix of water and IMPERMIX shall be controlled by the Contractor such that the density of the slurry shall be within an acceptable range as specified by the IMPERMIX supplier and as measured in accordance with API Specification 13A.
- C. Water: Water shall be clean, fresh, and free from oil, and excessive amounts of acid, alkali, organic matter, or other deleterious substances. Water will be provided at a source that will be identified by the Engineer. Conveying the water from the identified source to the point of use will be the responsibility of the Contractor. The Contractor is responsible for changes in the water chemistry and its effect on the slurry mixture. Water used in preparing the IMPERMIX slurry shall have a pH of between 6 and 8. The water shall contain no more than 750 mg/l total dissolved solids, and shall not have total hardness exceeding 150 mg/l. Use of electrical conductance to provide an indication of TDS will be acceptable.



8. EQUIPMENT

- A. The slurry cutoff wall shall be constructed using suitable equipment capable of attaining the required thickness, depth, and continuity of the wall.
- B. The vibrating beam shall have a web depth of 20 to 60 inches and a flange width of 10 to 15 inches.
- C. The slurry plant shall include the necessary equipment, including a colloidal mixer capable of producing a colloidal suspension of IMPERMIX (which is mechanically viscosified) and water, and the necessary sumps, holding tanks (with agitators if required), pumps, valves, hoses, supply lines, small tools, and all other equipment as may be required to adequately supply slurry to the storage tank and the slurry wall.
- D. The Contractor shall provide the laboratory equipment necessary for the testing required as specified herein.

9. EXECUTION OF THE WORK

- A. General: The Contractor shall be responsible for meeting all requirements listed below. Completed slurry wall sections failing to meet these requirements shall be repaired immediately to the satisfaction of the Engineer.
- B. Working Platform: Prior to slurry cutoff wall construction, a minimum 25-foot-wide working platform composed of up to about three (3) feet of compacted soil fill will be constructed along the proposed slurry wall alignment. The working platform will be approximately level from side to side. The longitudinal profile of the working platform is shown on the drawings. The slurry wall shall be constructed to the top surface of the working platform. Any trenching or excavation of the working platform shall not extend into native soils underlying the fill used to construct the working platform. Equipment storage and assembly areas will be constructed outside of the area to be enclosed by the slurry wall.
- C. Slurry: The slurry shall be pumped from the mixing plant into a holding tank only after the IMPERMIX has been hydrated. A slurry mixing area will be constructed prior to initiating placement of slurry.
- D. Beam Driving: The beam shall be inserted to the specified depth by a vibrating driver (unless use of a non-vibrating driver has been approved by the Engineer) at its maximum rate and shall be extracted at a rate of no more than 10 feet per minute. The pumping pressure of the slurry shall be such as to maintain a full trench level around the beam during extraction.



- E. Alignment: The beam shall be controlled by guide leads assuring plumbness in the vertical plane within the limits of plus or minus one percent (1%).
- F. Overlap and Change in Alignment: Each insertion of the beam shall overlap the previous insertion by a minimum of ten percent (10%) of the beam depth, or four (4) inches, whichever is least. At any changes in alignment of the slurry cutoff wall that are greater than 30 degrees, the first slurry panel shall be allowed to cure for a minimum of 24 hours before the second panel is driven through it.
- G. Wall Thickness: The completed slurry cutoff wall shall be plastic and continuous with no gaps and shall have a minimum thickness of 4 inches.
- H. Key: The bottom of the slurry cutoff wall will be keyed into the eluvial clay unit or the Denver Formation, as specified by the drawings. The key shall be a minimum of three (3) feet into the specified geologic unit (as determined by the Engineer), or until refusal, whichever is least.
- I. Hydraulic Conductivity: The average hydraulic conductivity of samples tested of the finished wall shall not exceed 1×10^{-7} cm/sec as determined in accordance with ASTM D-1587.
- J. Underground Obstructions: The geophysical screening described in Section 5D has been performed to minimize the potential for encountering unexploded ordnance or other subsurface obstructions that may prevent slurry wall construction. In the event that such obstructions are encountered, the Contractor shall immediately notify the Engineer, whereupon an alternate alignment shall be determined.
- K. Clean-up: After completion of slurry wall construction the Contractor shall dispose of all other materials or by-products as directed by the Engineer. Excess grout can be distributed over the ground surface within the area surrounded by the working platform, up to an elevation approximately 24 inches below the top of the working platform.

10. QUALITY CONTROL

- A. General: The Contractor shall maintain his own Quality Control for the slurry cutoff wall construction under the direction of a qualified Slurry Wall Specialist. The Contractor shall provide the necessary personnel, laboratory facilities and testing equipment to perform the specified tests.
- B. Continuity and Key: The Contractor shall be responsible for demonstrating, to the satisfaction of the Engineer, that the slurry wall is continuous, meets the specified minimum thickness of four (4) inches, and is keyed into the appropriate stratum the minimum specified depth as discussed herein. Slurry



wall continuity and depth shall be demonstrated by pulling a steel bar that extends to the bottom of the slurry cutoff wall horizontally through the entire wall. The bar shall be pulled through the in-place wall before the slurry hardens such that the slurry is permanently deformed by the presence or passage of the bar. At a minimum, the bar shall not be allowed to remain in slurry that has been in place for more than two (2) hours. When necessary to meet this requirement, such as at the end of each day, the bar shall be removed from the slurry wall. Slurry wall width shall be demonstrated by inserting a three and three quarters (3-3/4) inch template into fresh slurry to the total depth of the wall at a minimum spacing of 50 feet along the trench alignment, or more frequently if deemed by the Engineer to be necessary to verify minimum wall thickness.

C. Testing:

- 1) IMPERMIX Slurry: Testing for slurry density and viscosity (described in Section 7B), shall be performed a minimum of once each two (2) hours during working hours.
- 2) Hydraulic Conductivity: Hydraulic conductivity of the finished wall (as described in Section 9I) shall be determined at minimum wall spacings of 200 feet.
- 3) Filtrate Loss: Testing of the filtrate loss of the slurry (described in Section 7B) shall be performed each morning of each working day.
- 4) Water: Testing for pH, electrical conductance, and hardness (described in Section 7C) shall be performed at the beginning of the project, unless otherwise directed by the Engineer.

- D. Documentation: Results of all tests performed in accordance with this Specification shall be recorded by the Contractor on forms acceptable to the Engineer and signed by the Contractor's Slurry Wall Specialist. These forms shall be made available to the Engineer at all times for his inspection. Copies of all forms shall be submitted daily to the Engineer.

11. QUALITY ASSURANCE

- A. Testing: The Engineer may perform independent quality assurance testing on the slurry and backfill materials using the laboratory and equipment furnished by the Contractor. The testing will in no way relieve the Contractor of the responsibility of performing tests necessary to meet the construction requirements. The Contractor shall provide the necessary equipment and laboratory space for such testing to the Engineer on demand. Routine testing procedures being conducted by the Contractor shall be available for inspection by the Engineer.



- B. Testing Equipment: The Contractor shall furnish and maintain test equipment necessary to adequately perform the required testing. Procedures shall conform to applicable API specifications or other suitable methods as approved by the Engineer. The Contractor shall allow the Engineer access to testing equipment and test results without charge. The testing equipment shall include, but not necessarily be limited to: 1) Marsh Funnel viscometer and measuring cup (Baroid No. 201 and 202 or approved equal); 2) stop watch; 3) CO Cartridge Pressurized Filter Press System (Baroid No. 302-01 or approved equal); 4) pH dispenser with litmus paper (Baroid No. 625 or approved equal); 5) Approved equipment for determining hydraulic conductivity; and 6) Mud Balance (Baroid No. 140 or approved equal). Test results shall be reported to the Engineer within 24 hours of conducting a test.



SPECIFICATION 34-0272

ALLUVIAL GROUNDWATER MONITORING WELLS

CLIENT: SHELL OIL COMPANY

PROJECT: ROCKY MOUNTAIN ARSENAL REMEDIATION PROJECT

INTERIM RESPONSE ACTION FINAL DETAILED DESIGN

SHELL SECTION 36 TRENCHES IRA

LOCATION: ROCKY MOUNTAIN ARSENAL, COMMERCE CITY, CO



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SPECIFICATION 34-0274

ALLUVIAL GROUNDWATER MONITORING WELLS

1. SCOPE

- A. Seven alluvial groundwater monitoring wells will be constructed in the Shell Section 36 Trenches area. The groundwater monitoring wells will be installed for the purposes of monitoring groundwater quality and water levels up- and downgradient from the slurry cutoff wall. In addition to monitoring groundwater quality and water levels, five of the seven groundwater monitoring wells located downgradient from the slurry cutoff wall will constitute a means of detecting the presence of dense non-aqueous phase liquid (DNAPL).
- B. Geophysical techniques will be used to survey each borehole location prior to drilling activities for the presence of subsurface obstructions and unexploded ordnance.
- C. The groundwater monitoring wells have an average depth of approximately 11 ft and are expected to vary in approximate depth from 8 to 19 ft. The Contractor shall furnish equipment, labor and materials, and perform operations as required to construct each well. Typical design details are presented on the drawings.

2. RELATED WORK

- A. The following related work is covered in other specifications:
 - 1) Permanent Piezometers (Specification 34-0276)
 - 2) Well Abandonment (Specification 34-0274)
 - 3) Cast-In-Place Concrete (Specification 34-0301)

3. REFERENCE STANDARDS

- A. The organization whose standards are referenced herein is the American Petroleum Institute (API).

4. CONTRACTOR QUALIFICATIONS

- A. The Contractor shall submit evidence to the Engineer including: drilling experience in the Denver area and a list of available drilling and support equipment; and that they are competent to construct a groundwater



monitoring well of the design provided by the Engineer. This evidence should ensure that the Contractor will have sufficient experienced personnel to construct the groundwater monitoring wells. The Contractor shall supervise the groundwater monitoring well installation including borehole drilling, well construction, and well development.

5. ALLUVIAL GROUNDWATER MONITORING WELL DESCRIPTION

- A. The groundwater monitoring wells shall be constructed within an augered borehole of the diameter shown on the drawings to total depth. The groundwater monitoring well shall be completed with PVC slotted and blank casing, bottom cap or plug, top cap, well pack, bentonite seal, concrete, and a vented lockable well cover on a steel protective casing set in a reinforced concrete pad.

6. MATERIALS

- A. Blank Casing: The well casing shall be new, flush-threaded, PVC pipe of the dimensions shown on the drawings with a vented PVC top cap. Blank casing shall either be certified clean from the manufacturer and be received in sealed bags, or steam cleaned prior to use.
- B. Slotting Casing: The well shall be completed with new, flush-threaded PVC commercially slotted casing having slot spacers of 1/4 inch; and a solid, one-piece, flush-threaded PVC bottom cap or plug. Slot size and well screen dimensions are shown on the drawings. Well screen shall either be certified clean from the manufacturer and be received in sealed bags, or steam cleaned prior to use.
- C. Well Pack: The well pack shall consist of washed silica sand as produced by Colorado Silica Sand or approved equal of the graded size shown on the drawings. Well pack characteristics may be changed by the Engineer depending upon subsurface geologic conditions encountered during borehole drilling.
- D. Bentonite: The bentonite shall be sodium cation base montmorillonite, premium grade Wyoming-type bentonite, which conforms to the most recent applicable API specifications. The Contractor shall submit a certificate of compliance. Bentonite shall be protected from moisture during transit and storage.
- E. Water: A source of water for use during drilling or well construction operations will be identified by the Engineer. The Contractor is responsible for transporting water to each well site.



- F. Protective Casing: A carbon steel pipe of the dimensions shown on the drawings shall be used for the surface protective casing. The steel casing shall have a metal, lockable well cover (MAASS 6LCR or approved equal).
- G. Cement: Type II Portland cement shall be used for applications requiring cement.

7. EQUIPMENT

- A. Drilling of the alluvial groundwater monitoring wells shall be accomplished by use of a suitable hollow-stem auger or other well drilling rig not requiring drilling fluid for operation. The drilling rig shall have the capabilities of successfully drilling and completing wells of the type and size shown on the drawings to a depth of up to approximately 19 feet. The Contractor shall have the capability of installing the required PVC casing string, well pack, bentonite seal, concrete, protective casing, and concrete well pad.

8. WELL CONSTRUCTION

- A. General: Alluvial groundwater monitoring wells shall be completed approximately as discussed in the following sections. Site-specific geologic conditions may require changes to well construction plans. Modifications to construction specifications must be approved in advance in writing by the Engineer. Each activity must be completed to the satisfaction of the Engineer.
- B. Borehole: A borehole of the diameter shown on the drawings shall be drilled to penetrate into the alluvium. Depth into the alluvium will be verified by the Engineer.
- C. Well String: A well string consisting of commercially slotted casing with bottom cap or plug, and blank casing with top cap shall be constructed to the dimensions shown on the drawings. The blank casing shall extend to approximately 3 inches below the top of the protective casing. All casing joints shall be flush threaded.
- D. Well Pack: A well pack of washed silica sand extending from the total depth of the borehole to the depth above the slotted casing shown on the drawings shall be placed. The well pack shall fill the annulus between the well string and the borehole wall.
- E. Annular Seal: A hydrated bentonite seal of the dimensions shown on the drawings shall be placed on top of the well pack. Concrete shall be placed from the bentonite seal to the level shown on the drawings. Well construction operations shall be conducted continuously from the beginning of well pack placement until the concrete is placed. Additional concrete will be added as



necessary to maintain the concrete level at the desired level. The concrete shall be machine or hand mixed to the satisfaction of the Engineer.

F. Surface Completion:

- 1) Protective Casing: A carbon steel pipe with a vented, lockable cover, extending from 3 ft below finish grade to 2 ft above the well pad and painted yellow shall be installed. The casing shall extend more than 2 feet above the well pad if the depth to the top of the bentonite seal is 3 feet or less. In any case, the steel casing shall not penetrate into the bentonite seal.
- 2) Reinforced Concrete Pad: A reinforced concrete pad shall be constructed as shown on the drawings.

G. Drill Cuttings: Drill cuttings produced during drilling operations shall be considered potentially contaminated. These cuttings shall be secured in 55-gallon drums provided and disposed of as directed by the Engineer.

H. Surveying: The ground surface elevation, the elevation of the top of casing, and the location coordinates of the alluvial monitoring wells will be surveyed by the Engineer.

9. WELL DEVELOPMENT

- A. The wells shall be developed by the Contractor following completion of well construction activities. Well development shall be conducted by alternately surging and bailing each well as directed by the Engineer, and shall include surging of all screened sections of the aquifer. Surging shall be performed by use of a surge block or bailer having an outside diameter no more than 1-inch smaller nor more than 25 percent smaller than the inside diameter of the well screen. Wells shall be developed for a minimum of two hours, or until discharge water during surging of all screened well sections are essentially free of sand, whichever is greater. Water removed from a well during development shall be visually monitored for sand content and turbidity. The total volume of water removed during well development shall be recorded by the Engineer. The Contractor shall place water generated during well development activities into suitable drums or tanks provided and disposed of as directed by the Engineer.

10. CLEANUP

- A. At completion and before acceptance of this work, all equipment, surplus materials and rubbish shall be removed, leaving the site in a neat, presentable condition acceptable to the Engineer.



11. QUALITY CONTROL

- A. General: The Contractor shall maintain records as required by the Engineer to assure that well construction is being conducted within contract limits. The results of drilling, well construction, and well development activities shall be documented to assure they meet specifications. The Contractor shall maintain records of observations, measurements and tests performed. These records shall be furnished to the Engineer no later than 24 hours after the tests, measurements, and/or observations are made.
- B. Well Construction Log: The Contractor and Engineer shall each maintain logs of daily activities. A well construction log shall be maintained by both the Engineer and Contractor which shall document well construction and shall also identify subsurface geologic occurrences encountered during drilling and well construction. The depths to the water table and contacts between geologic units shall be identified.



SPECIFICATION 34-0274

WELL ABANDONMENT

CLIENT: SHELL OIL COMPANY

PROJECT: ROCKY MOUNTAIN ARSENAL REMEDIATION PROJECT

INTERIM RESPONSE ACTION FINAL DETAILED DESIGN

SHELL SECTION 36 TRENCHES IRA

LOCATION: ROCKY MOUNTAIN ARSENAL, COMMERCE CITY, CO



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SPECIFICATION 34-0274

WELL ABANDONMENT

1. SCOPE

A. General:

Nine wells and ten piezometers ("well points" on drawings) located inside the area to be enclosed by the slurry cutoff wall and six wells located outside of the enclosed area shall be abandoned prior to installation of the soil and vegetative cover. The wells located inside the enclosed area shall be closed to facilitate construction of the soil and vegetative cover. The wells located outside of the enclosed area shall be closed because they are of unknown or unreliable construction. Ten additional wells located outside of the proposed enclosed area are of known and reliable construction but may be screened over multiple hydrogeologic units. These wells shall be considered for closure once additional information is available. A brief description of each well is presented below. The wells are expected to vary in depth from approximately 9 to 119 ft. The Contractor shall furnish equipment, labor and material, and perform operations as required to abandon each well.

B. Wells Located Inside the Slurry Wall:

- 1) Well 36163 (Alluvium): Installed in January 1987, Well 36163 has a borehole depth of 16.5 ft and a casing depth of 16.5 ft. The borehole diameter is 12.25 inches and the casing diameter is 4.0 inches. This well is screened from 10.7 to 16.5 ft in the alluvium.
- 2) Well 36164 (Alluvium): Well 36164, installed in January 1987, has a borehole depth of 13.5 ft and a casing depth of 13.0 ft. The borehole diameter is 12.25 inches and the casing diameter is 4.0 inches. This well is screened from 7.51 to 13.0 ft in the alluvium.
- 3) Well 36516 (Alluvium): Installed in September 1989, Well 36516 has a borehole depth of 24.0 ft and a casing depth of 21.5 ft. The borehole diameter is 7.63 inches and the casing diameter is 2.0 inches. This well is screened from 6.5 to 21.5 ft in the alluvium.
- 4) Well 36518 (Alluvium): Well 36518, installed in September 1989, has a borehole depth of 14.2 ft and a casing depth of 14.2 ft. The borehole diameter is 7.63 inches and the casing diameter is 2.0 inches. This well is screened from 9.2 to 14.2 ft in the alluvium.
- 5) Well 36519 and Piezometers (Alluvium): Installed in March 1989, Well 36519 has a borehole depth of 11.5 ft and a casing depth of 11.3 ft. The borehole diameter is 7.75 inches and the casing diameter is 2.0



inches. This well is screened from 6.3 to 11.3 ft in the alluvium. Ten well points, installed in April 1990, each have total depths of 10.8 ft.

- 6) Well 36520 (Alluvium): Installed in March 1989, Well 36520 has a borehole depth of 9.5 ft and a casing depth of 9.0 ft. The borehole diameter is 7.75 inches and the casing diameter is 2.0 inches. This well is screened from 4.0 to 9.0 ft in the alluvium.
- 7) Well 36590 (Alluvium and Upper Denver Formation): Well 36590, installed in June 1980, has a borehole depth of 29.0 ft and a casing depth of 28.0 ft. The borehole diameter is 8.0 inches and the casing diameter is 4.0 inches. This well is screened from 18.0 to 28.0 ft in the alluvium and upper Denver Formation.
- 8) Well 36591 (Alluvium and Upper Denver Formation): Installed in June 1980, Well 36591 has a borehole depth of 28.0 ft and a casing depth of 28.0 ft. The borehole diameter is 8.0 inches and the casing diameter is 4.0 inches. This well is screened from 18.0 to 28.0 ft in the alluvium and upper Denver Formation.
- 9) Well 36592 (Alluvium and Upper Denver Formation): Well 36592, installed in June 1980, has a borehole depth of 28.0 ft and a casing depth of 28.0 ft. The borehole diameter is 8.0 inches and the casing diameter is 4.0 inches. This well is screened from 18.0 to 28.0 ft in the alluvium and upper Denver Formation.

C. Wells of Unknown or Unreliable Construction

- 1) Well 36063 (Alluvium): Installed in August 1978, Well 36063 has a borehole depth of 23.7 ft and a casing depth of 23.7 ft. The borehole diameter is unknown and the casing diameter is 2.0 inches. This well is screened from 18.3 to 21.7 ft in the alluvium. There is no information on grout or well pack.
- 2) Well 36064 (Confined Denver Formation): Installed in August 1978, Well 36064 has a borehole depth of 119.6 ft and a casing depth of 119.0 ft. The borehole diameter is unknown and the casing diameter is 2.0 inches. This well is screened from 70.2 to 73.6 ft in the confined Denver Formation. There is a 45.4-ft long interval between the bottom of the screen and the total depth drilled.
- 3) Well 36065 (Alluvium): Installed in August 1978, Well 36065 has a borehole depth of 24.0 ft and a casing depth of 24.0 ft. The borehole diameter is unknown and the casing diameter is 2.0 inches. This well is screened from 17.6 to 21.0 ft in the alluvium. There is no information on grout or well pack.



- 4) Well 36066 (Confined Denver Formation): Well 36066 installed in August 1978, is a deep twin to Well 36065. This well has borehole depth of 114.9 ft and a casing depth of 114.0 ft. The borehole diameter is unknown and the casing diameter is 2.0 inches. The well is screened in the confined Denver Formation from 73.3 ft to 76.7 ft and has 37.3 ft of casing below the screen.
- 5) Well 36067 (Alluvium): Installed in July 1978, Well 36067 has a borehole depth of 24.5 ft and a casing depth of 24.5 ft. The borehole diameter is unknown and the casing diameter is 2.0 inches. This well is screened from 10.4 to 13.4 ft in the alluvium. The well has 11.1 ft of casing below the screened interval.
- 6) Well 36104 (Confined Denver Formation): Well 36104, installed in July 1978, has a borehole depth of 112.8 ft and a casing depth of 112.7 ft. This well is the deep twin to Well 36067. The borehole diameter is unknown and the casing diameter is 2.0 inches. The well is screened in the confined Denver Formation from 92.0 ft. to 99.0 ft. There is 13.7 ft between the bottom of the screen and the total depth drilled.

D. Wells of Known or Reliable Construction

- 1) Well 36504 (Alluvium): Installed in March 1989, Well 36504 has a borehole depth of 21.0 ft and a casing depth of 18.0 ft. The borehole diameter is 10.0 inches and the casing diameter is 4.0 inches. This well is screened from 3.0 to 18.0 ft in the alluvium.
- 2) Well 36505 (Alluvium and Upper Denver Formation): Well 36505, installed in March 1989, has a borehole depth of 13.0 ft and a casing depth of 13.0 ft. The borehole diameter is 10.0 inches and the casing diameter is 4.0 inches. This well is screened from 3.0 to 13.0 ft in the alluvium and upper Denver Formation.
- 3) Well 36506 (Alluvium and Upper Denver Formation): Installed in March 1989, Well 36506 has a borehole depth of 23.0 ft and a casing depth of 23.0 ft. The borehole diameter is 10.0 inches and the casing diameter is 4.0 inches. This well is screened from 3.0 to 23.0 ft in the alluvium and Upper Denver Formation.
- 4) Well 36507 (Alluvium): Well 36507, installed in April 1989, has a borehole depth of 22.0 ft and a casing depth of 19.0 ft. The borehole diameter is 10.0 inches and the casing diameter is 4.0 inches. This well is screened from 4.0 to 19.0 ft in the alluvium.
- 5) Well 36508 (Alluvium): Installed in March 1989, Well 36508 has a borehole depth of 25.5 ft and a casing depth of 22.3 ft. The borehole diameter is 10.0 inches and the casing diameter is 4.0 inches. This well is screened from 2.3 to 22.3 ft in the alluvium.



- 6) Well 36509 (Alluvium): Well 36509, installed in April 1989, has a borehole depth of 14.0 ft and a casing depth of 14.0 ft. The borehole diameter is 10.0 inches and the casing diameter is 4.0 inches. This well is screened from 4.0 to 14.0 ft in the alluvium.
- 7) Well 36510 (Alluvium): Well 36510, a twin to Well 36509 installed in April 1989, has a borehole depth of 26.0 ft and a casing depth of 24.0 ft. The borehole diameter is 10.0 inches and the casing diameter is 4.0 inches. This well is screened from 19.0 to 24.0 ft in the alluvium.
- 8) Well 36514 (Alluvium): Installed in September 1989, Well 36514 has a borehole depth of 24.0 ft and a casing depth of 21.4 ft. The borehole diameter is 7.63 inches and the casing diameter is 2.0 inches. This well is screened from 6.4 to 21.4 ft in the alluvium.
- 9) Well 36515 (Alluvium): Well 36515, installed in September 1989, has a borehole depth of 19.0 ft and a casing depth of 17.0 ft. The borehole diameter is 7.63 inches and the casing diameter is 2.0 inches. This well is screened from 7.0 to 17.0 ft in the alluvium.
- 10) Well 36593 (Alluvium and Upper Denver Formation): Installed in June 1980, Well 36593 has a borehole depth of 28.0 ft and a casing depth of 28.0 ft. The borehole diameter is 8.0 inches and the casing diameter is 4.0 inches. This well is screened from 18.0 to 28.0 ft in the alluvium and Upper Denver Formation.

2. RELATED WORK

A. The following related work is covered in other specifications:

- 1) Permanent Piezometers (Specification 34-0276)
- 2) Alluvial Groundwater Monitoring Wells (Specification 34-0272)

3. REFERENCE STANDARDS

A. The organization whose standards are referenced herein are the American Petroleum Institute (API) and the State of Colorado Division of Water Resources Revised and Amended Rules and Regulations of the Board of Examiners of Water Well Construction and Pump Installation Contractors, Rule II Abandonment.

4. CONTRACTOR QUALIFICATIONS

A. The Contractor shall submit evidence to the Engineer including: well abandonment experience in the Denver area and a list of available drilling and support equipment; and that they are competent to abandon wells. This



evidence will ensure that the Contractor will have sufficient experienced personnel to abandon the monitoring wells. The Contractor shall supervise the well abandonment including well cleaning and inspection, overdrilling, and removal of the well string, if possible, or abandonment in place, and grouting to surface.

5. WELL ABANDONMENT DESCRIPTION

- A. A rotary drilling rig shall be available for on site use until the project reaches completion or as directed by the Engineer. The well casing and screen shall be cleaned out to the bottom by drilling, bailing, blowing, and/or washing out materials within the casing, or as directed by the Engineer. Because most of the wells are shallow (less than 30 ft), the casing and screen shall be removed by overdrilling and/or pulling. If the casing and screen are not removable by overdrilling or pulling, it shall be necessary to drill them out. Well pads at the ground surface may be removed at the discretion of the Engineer. The Engineer will make this determination at each site.
- B. Following the removal of the casing and screen, the borehole shall be immediately backfilled with IMPERMIX from total depth, if possible, to the ground surface prior to changing locations. The well string shall be treated as a hazardous waste and drummed accordingly. Well points shall be decontaminated and retained for future use, if appropriate, or drummed as hazardous waste, depending upon their condition, as determined by the Engineer.

6. MATERIALS

- A. Grout: The grout shall consist of a stable colloidal suspension of IMPERMIX, which is a self-hardening slurry that is mechanically viscosified. The IMPERMIX shall be of the type sold by Enviro-Trench Company, Pelham, New York, or Engineer-approved equal.
- B. Water: A source of water for use during drilling operations will be identified by the Engineer. The Contractor is responsible for transporting water to each site.

7. EQUIPMENT

- A. Well abandonment shall be accomplished by use of a drilling rig and equipment appropriate for well inspection, cleaning, and closure activities such as fishing and perforating tools, casing knife, tremie pipe, welding equipment, fire extinguisher, etc.
- B. The Contractor shall have the capabilities of removing the well strings from the subsurface and of pressure grouting the boreholes from total depth to the surface, as necessary.



8. WELL ABANDONMENT

- A. General: Well abandonment shall be completed approximately as discussed in the following sections. Site-specific conditions may require changes to well abandonment plans. Modifications to abandonment specifications must be approved in advance in writing by the Engineer. Each activity must be completed to the satisfaction of the Engineer.
- B. Closure Methods: Closure methods shall include the removal, to the extent possible, of materials which hinder the sealing operation, including casing and screen. If the well string appears to be in good condition attempts shall be made to remove it by fishing with cables or tools. If the well string appears to be in poor condition attempts shall be made to overdrill or overwash the well string to facilitate its removal. If the well string cannot be removed, it shall be torn or perforated to allow the grout to completely seal the annular space. This shall be accomplished by using a perforating tool or a casing knife.
- C. Inspection and Cleaning: The depth to the water table and the depth to the bottom of the well shall be measured prior to cleaning, if possible. Surface casing shall be installed, if appropriate. The casing shall be washed using appropriate techniques, or as directed by the Engineer. If there are no obstructions, the casing and well screen shall be drilled out to the bottom of the borehole using appropriate techniques, or as directed by the Engineer. If obstructions are encountered, the obstructions shall be fished or drilled out. The casing and screen shall be cleaned to the bottom of the borehole using suitable methods, or as directed by the Engineer. The measured depth shall be compared to historical records.

If a well has been previously abandoned and is filled with cement or grout, an additional record search shall be conducted to document the earlier abandonment. If records are not available, the well shall be redrilled and the borehole shall be regROUTED to insure proper closure, as directed by the Engineer.

- D. Standard Well Closure for Alluvial Wells: The casing and well screen shall be over-augured to a depth of 5 ft below the bottom of the existing well using appropriate methods, or as directed by the Engineer. The well string shall be removed using suitable methods, or as directed by the Engineer. The grout shall be mixed by machine or hand-methods. The grout shall be emplaced from the total depth, if possible, to the ground surface using the tremie pipe or other appropriate method, as directed by the Engineer.
- E. Standard Closure for Denver Formation Wells: The well string shall be overwashed using appropriate methods, or as directed by the Engineer. The inner casing and well screen shall be removed using suitable methods, or as directed by the Engineer. The grout shall be emplaced over the uncased section of the Denver Formation using a tremie pipe. The surface casing



shall be overdrilled or over-augured using suitable methods, or as directed by the Engineer. The grout shall be emplaced in the alluvium as the surface casing is being removed using the tremie pipe or other appropriate method, as directed by the Engineer.

- F. Drill Cuttings: Drill cuttings or fine debris shall be collected in 55-gallon drums for storage. Cleaning fluid or other liquids shall be collected in 55-gallon polyethylene drums for storage, if possible.

9. CLEANUP

- A. At completion and before acceptance of this work, all equipment, surplus materials and rubbish shall be removed, leaving the site in a neat, presentable condition acceptable to the Engineer.

10. QUALITY CONTROL

- A. General: The Contractor shall maintain records as required by the Engineer to assure that well abandonment is being conducted within contract limits. The results of well abandonment activities shall be documented to assure they meet specifications. The Contractor shall maintain records of observations, measurements and tests performed. These records shall be furnished to the Engineer no later than 24 hours after the observations, measurements, and/or tests are made.
- B. Well Closure Form: The Contractor and Engineer shall each maintain logs of daily activities. A well closure record shall be maintained by both the Engineer and Contractor and shall identify conditions encountered during well abandonment. The depth to the water table shall be identified.



SPECIFICATION 34-0276
PERMANENT PIEZOMETERS

CLIENT: SHELL OIL COMPANY

PROJECT: ROCKY MOUNTAIN ARSENAL REMEDIATION PROJECT

INTERIM RESPONSE ACTION FINAL DETAILED DESIGN

SHELL SECTION 36 TRENCHES IRA

LOCATION: ROCKY MOUNTAIN ARSENAL, COMMERCE CITY, CO



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SPECIFICATION 34-0276

PERMANENT PIEZOMETERS

1. SCOPE

- A. Five pairs of permanent piezometers will be installed in the eolian sand unit to monitor water levels both inside and outside of the area enclosed by the slurry cutoff wall proposed for the Shell Section 36 Trenches area.
- B. Geophysical techniques will be used to survey each borehole location for the presence of subsurface obstructions and unexploded ordnance prior to drilling activities.
- C. The 10 piezometers are expected to vary in approximate depth from 9 to 15 ft. The Contractor shall furnish equipment, labor and materials, and perform operations as required to construct each piezometer. Typical design details are presented on the drawings.

2. RELATED WORK

- A. The following related work is covered in other specifications:
 - 1) Well Abandonment (Specification 34-0274)
 - 2) Alluvial Groundwater Monitoring Wells (Specification 34-0272)
 - 3) Cast-In-Place Concrete (Specification 34-0301)

3. REFERENCE STANDARDS

- A. The organization whose standards are referenced herein is the American Petroleum Institute (API).

4. CONTRACTOR QUALIFICATIONS

- A. The Contractor shall submit evidence to the Engineer including: drilling experience in the Denver area and a list of available drilling and support equipment; and competence to construct a piezometer of the design provided by the Engineer. This evidence should ensure that the Contractor will have sufficient experienced personnel to construct the piezometers. The Contractor shall supervise the piezometer installation including borehole drilling, piezometer construction, and piezometer development.



5. PIEZOMETER DESCRIPTION

- A. The piezometers shall be installed within an auger borehole of the diameter shown on the drawings to total depth. The piezometer shall be completed with PVC slotted and blank casing, bottom plug, top cap, well pack, bentonite seal, concrete, and a vented lockable well cover on a steel protective casing set in a reinforced concrete well pad.

6. MATERIALS

- A. Blank Casing: The piezometer casing shall be new flush-threaded PVC pipe with a vented PVC top cap. Blank casing shall either be certified clean from the manufacturer and be received in sealed bags, or steam cleaned prior to use.
- B. Slotted Casing: The piezometer shall be completed with new flush-threaded PVC commercially slotted casing having slot spacers of 1/4 inch; and a solid, one-piece, flush-threaded PVC bottom cap or plug. Slot size and slotted casing dimensions are shown on the drawings. Slotted casing shall either be certified clean from the manufacturer and be received in sealed bags, or steam cleaned prior to use.
- C. Well Pack: The well pack shall consist of washed silica sand as produced by Colorado Silica Sand or approved equal of the graded size shown on the drawings. Well pack characteristics may be changed by the Engineer depending upon subsurface geologic conditions encountered during borehole drilling.
- D. Bentonite: The bentonite shall be sodium cation base montmorillonite, premium grade Wyoming-type bentonite, which conforms to the most recent applicable API specifications. The Contractor shall submit a certificate of compliance. Bentonite shall be protected from moisture during transit and storage.
- E. Water: A source of water for use during drilling or piezometer installation will be identified by the Engineer. The Contractor is responsible for transporting water to each piezometer site.
- F. Protective Casing: A carbon steel pipe of the dimensions shown on the drawings shall be used for the surface protective casing. The steel casing shall have a metal, lockable well cover (MAASS 6LCR or approved equal).
- G. Cement: Type II Portland cement shall be used for applications requiring cement.



7. EQUIPMENT

- A. Drilling of the piezometer borehole shall be accomplished by use of a suitable hollow-stem auger or other well drilling rig not requiring drilling fluid for operation. The drilling rig shall have the capabilities of successfully drilling and completing piezometers of the type and size shown on the drawings to a depth of up to approximately 15 feet. The Contractor shall have the capability of installing the required PVC casing string, well pack, bentonite seal, concrete, protective casing, and concrete pad.

8. PIEZOMETER CONSTRUCTION

- A. General: Piezometers shall be completed approximately as discussed in the following sections. Site-specific geologic conditions may require changes to piezometer construction plans. Modifications to construction specifications must be approved in advance in writing by the Engineer. Each activity must be completed to the satisfaction of the Engineer.
- B. Borehole: A borehole of the diameter shown on the drawings shall be drilled to penetrate into the alluvium. Depth into the alluvium will be verified by the Engineer.
- C. Well String: A well string consisting of commercially slotted casing with bottom cap or plug, and blank casing with top cap above the slotted casing shall be constructed to the dimensions shown on the drawings. The relationship between the screened interval and the water table will vary for individual piezometers. The blank casing shall extend to approximately 3 inches below the top of the protective casing. All casing joints shall be flush threaded.
- D. Well Pack: A well pack of washed silica sand extending from the total depth of the borehole to the depth above the slotted casing shown on the drawings shall be placed. The well pack shall fill the annulus between the well string and the borehole wall.
- E. Annular Seal: A hydrated bentonite seal of the dimensions shown on the drawings shall be placed on top of the well pack. Concrete shall be placed from the bentonite seal to the level shown on the drawings. Piezometer construction operations shall be conducted continuously from the beginning of well pack placement until the concrete is placed. Additional concrete will be added as necessary to maintain the concrete at the desired level. The concrete shall be machine or hand mixed to the satisfaction of the Engineer.



F. Surface Completion:

- 1) Protective Casing: A carbon steel pipe with a vented, lockable cover, extending from 3 ft below finish grade to 2 ft above the well pad and painted yellow shall be installed. The casing shall extend more than 2 feet above the well pad if the depth to the top of the bentonite seal is 3 feet or less. In any case, the steel casing shall not penetrate into the bentonite seal.
- 2) Reinforced Concrete Pad: A reinforced concrete pad shall be constructed as shown on the drawings.

G. Borehole Drill Cuttings: Borehole drill cuttings produced during drilling operations shall be considered potentially contaminated. These cuttings shall be secured in 55-gallon drums provided and disposed of as directed by the Engineer.

H. Surveying: The ground surface elevation, the elevation of the top of casing, and the location coordinates of the piezometers will be surveyed by the Engineer.

9. PIEZOMETER DEVELOPMENT

A. The piezometers shall be developed by the Contractor following completion of piezometer construction activities. Piezometer development shall be conducted by alternately surging and bailing each piezometer as directed by the Engineer, and shall include surging of all screened sections of the aquifer. Surging shall be performed by use of a surge block or bailer having an outside diameter no more than 1-inch smaller nor more than 25 percent smaller than the inside diameter of the well screen. Piezometers shall be developed for a minimum of two hours, or until discharge water during surging of all screened sections is essentially free of sand, whichever is greater. Water removed from a piezometer during development shall be visually monitored for sand content and turbidity. The total volume of water removed during piezometer development shall be recorded by the Engineer. The Contractor shall place water generated during piezometer development activities into suitable drums or tanks provided and disposed of as directed by the Engineer.

10. CLEANUP

A. At completion and before acceptance of this work, all equipment, surplus materials and rubbish shall be removed, leaving the site in a neat, presentable condition acceptable to the Engineer.



11. QUALITY CONTROL

- A. General: The Contractor shall maintain records as required by the Engineer to assure that piezometer construction is being conducted within contract limits. The results of drilling, piezometer construction, and piezometer development activities shall be documented to assure they meet specifications. The Contractor shall maintain records of observations, measurements and tests performed. These records shall be furnished to the Engineer no later than 24 hours after the tests, measurements, and/or observations are made.
- B. Piezometer Construction Log: The Contractor and Engineer shall each maintain logs of daily activities. A piezometer construction log shall be maintained by both the Engineer and Contractor which shall document piezometer construction and shall also identify subsurface geologic occurrences encountered during drilling and piezometer construction. The depths to the water table and the base of the eolian sand unit shall be identified.



SPECIFICATION 34-0301
CAST-IN-PLACE CONCRETE

CLIENT: SHELL OIL COMPANY

PROJECT: ROCKY MOUNTAIN ARSENAL REMEDIATION PROJECT

INTERIM RESPONSE ACTION FINAL DETAILED DESIGN

SHELL SECTION 36 TRENCHES IRA

LOCATION: ROCKY MOUNTAIN ARSENAL, COMMERCE CITY, CO



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| 5. | MATERIAL | 4 |
| 6. | FINISH | 4 |
| 7. | CURING | 4 |



SPECIFICATION 34-0301

CAST-IN-PLACE CONCRETE

1. SCOPE

- A. The cast-in-place concrete requirements consist of the welded wire fabric reinforced concrete aprons at wells and piezometers, and the concrete used in constructing the steel protective posts as shown on the design drawings.
- B. This specification applies for the above said type of work. In the event that other more extensive cast-in-place concrete becomes necessary, other appropriate specifications will be issued.

2. RELATED WORK

- A. The following related work is covered in other specifications:
 - 1) Site Preparation, Grading, Excavating, and Backfilling (Specification 34-0212)
 - 2) Alluvial Monitoring Wells (Specification (34-0272)
 - 3) Permanent Piezometers (Specification 34-0276)

3. REFERENCE STANDARDS

- A. Organizations whose standards are referenced herein include the following:
 - 1) ACI - American Concrete Institute
 - 2) ASTM - American Society for Testing and Materials
- B. Any references to the above standards shall be the edition in effect as of the date of this specification unless otherwise stated.
- C. For standards referred to in ACI 301, the edition and supplements in use and currently available at date of this Specification 34-0301 shall apply.

4. GENERAL

- A. Shop Drawings: None are required and none will be furnished. Cast-in-place concrete shall be located and sized as required by the design drawings.



- B. Earth Compaction: The earth upon which each of the aprons will bear, shall be undisturbed soil.

5. MATERIALS

- A. Concrete: 3,000 psi or commercial dry mix for pouring small quantities.
- B. Portland Cement: ASTM C150, Type II.
- C. Sand: ASTM C144, washed natural sand, free from impurities.
- D. Aggregate: Washed natural aggregate maximum 1/2 inch size, free from impurities.
- E. Water: Free of deleterious amount of acids, alkalis, and organic materials.
- F. Forms: Wood, steel, or other Engineer approved material; or excavated surfaces.

6. FINISH

- A. Trowl finish the concrete aprons at wells and piezometers.

7. CURING

- A. Requirements for curing and protection shall be as specified in ACI 301.

IMPLEMENTATION DOCUMENT
FOR OTHER CONTAMINATION SOURCES
INTERIM RESPONSE ACTION
SHELL SECTION 36 TRENCHES, RMA

VOLUME 3 ENGINEERING DRAWINGS

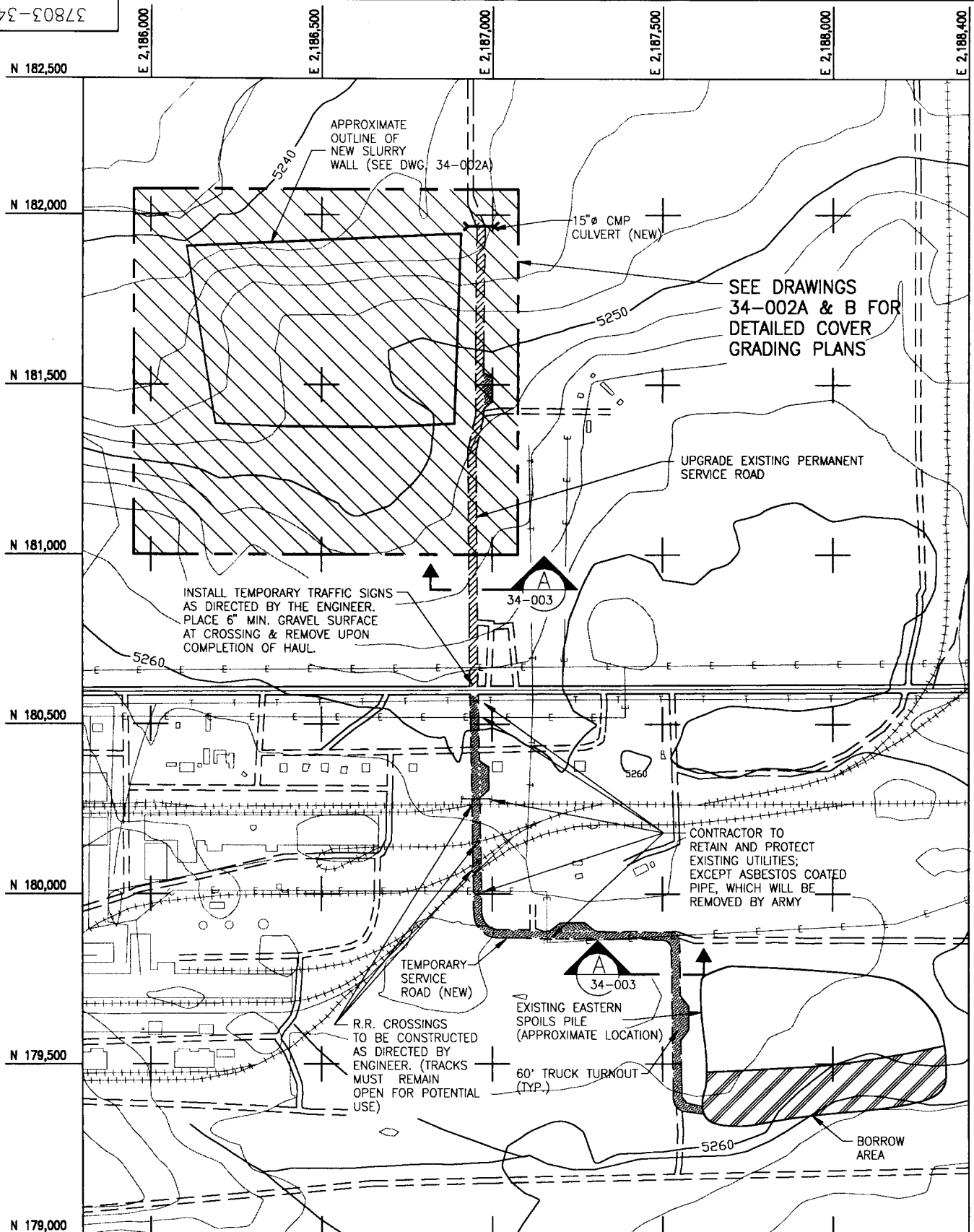
FINAL

March 1991

Prepared by
Morrison-Knudsen Corporation
Environmental Services Group
Denver, Colorado 80203

Prepared for
Shell Oil Company
Denver, Colorado 80203

37803-34-001



REFERENCE DWGS

| | |
|-------------|--|
| 34-002A | COVER GRADING PLAN / COMPACTED LAYER |
| 34-002B | COVER GRADING PLAN / TOPSOIL LAYER |
| 34-003 | SOIL / GROUNDWATER MONITORING & ROAD DETAILS |
| DRAWING NO. | TITLE |

REVISIONS

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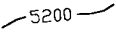





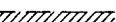



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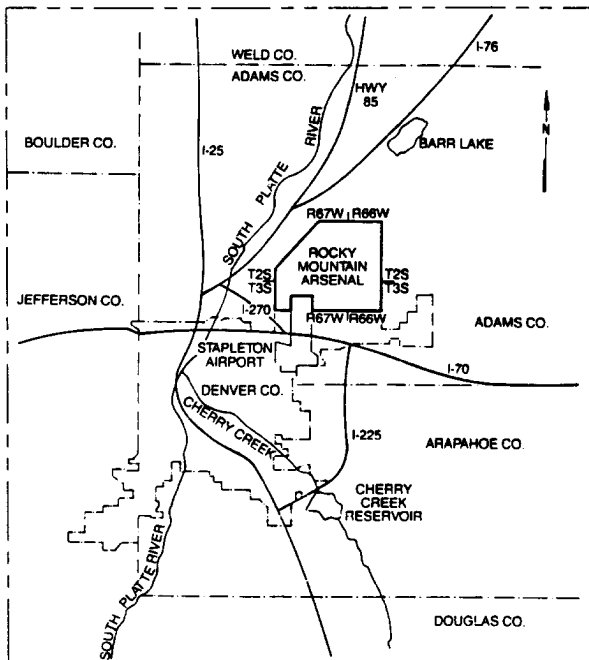
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|  | TEMPORARY SERVICE ROAD (NEW) |
|  | PERMANENT SERVICE ROAD |
|  | RAILROAD TRACKS |
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|  | AERIAL POWER POLE LINE |
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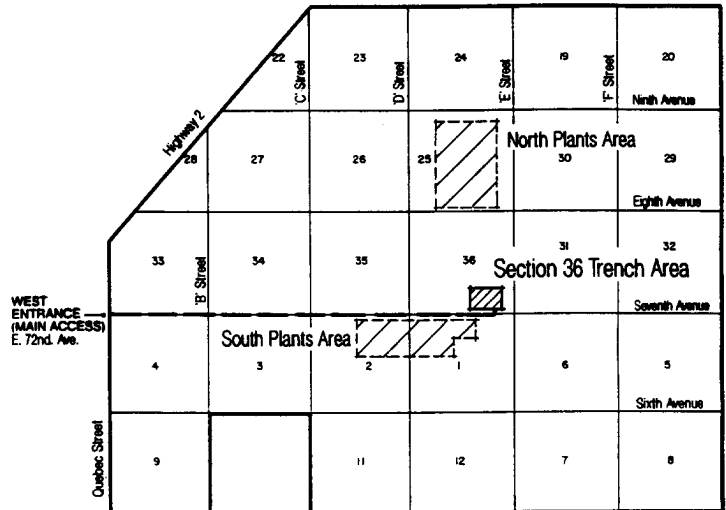
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| 34-002A | COVER GRADING PLAN / COMPACTED LAYER |
| 34-002B | COVER GRADING PLAN / TOPSOIL LAYER |
| 34-003 | SOIL/GROUNDWATER MONITORING & ROAD DETAILS |
| 34-004 | SLURRY WALL PROFILE & DETAILS SHEET 1 |
| 34-005 | SLURRY WALL PROFILE & DETAILS SHEET 2 |
| 34-006 | COVER CROSS SECTIONS SHEET 1 |
| 34-007 | COVER CROSS SECTIONS SHEET 2 |
| 34-008 | COVER CROSS SECTIONS SHEET 3 |
| 34-009 | COVER CROSS SECTIONS SHEET 4 |

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LOCATION MAP



CONTRACTOR ACCESS

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MORRISON KNUDSEN CORPORATION
ENVIRONMENTAL SERVICES GROUP

SHELL OIL COMPANY

ROCKY MOUNTAIN ARSENAL REMEDIATION PROJECT
INTERIM RESPONSE ACTION FINAL DETAILED DESIGN

CAD FILE NAME: 803C01A

SHELL SECTION 36 TRENCHES
INTERIM RESPONSE ACTION

DRAWING TITLE

SITE PLAN/
TITLE DRAWING

WORK ORDER

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DRAWING NO.

37803-34-001

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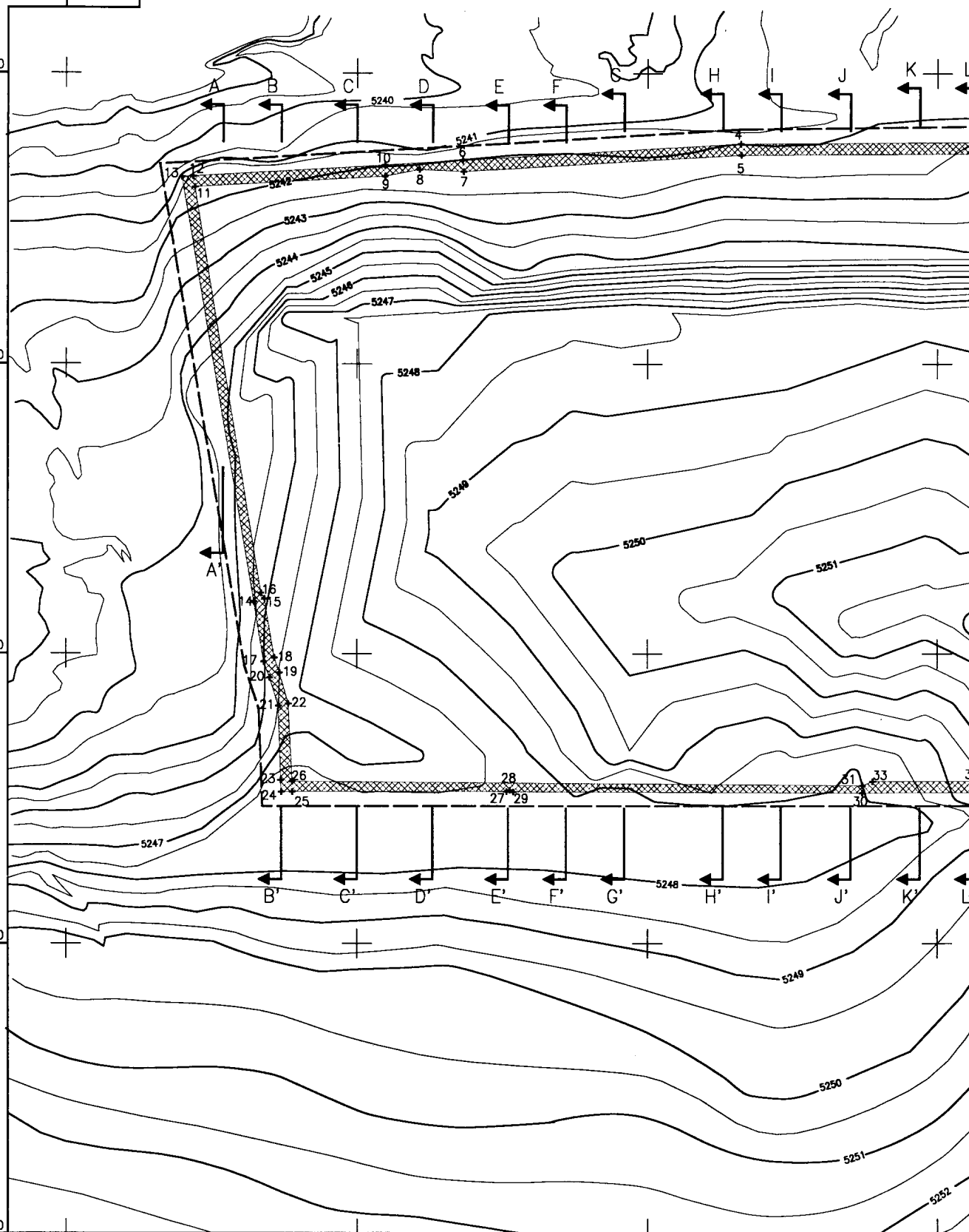
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| 34-004 | SLURRY WALL PROFILE & DETAILS SHEET 1 |
| 34-005 | SLURRY WALL PROFILE & DETAILS SHEET 2 |
| 34-006 | COVER CROSS SECTIONS SHEET 1 |
| 34-007 | COVER CROSS SECTIONS SHEET 2 |
| 34-008 | COVER CROSS SECTIONS SHEET 3 |
| 34-009 | COVER CROSS SECTIONS SHEET 4 |
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REVISIONS

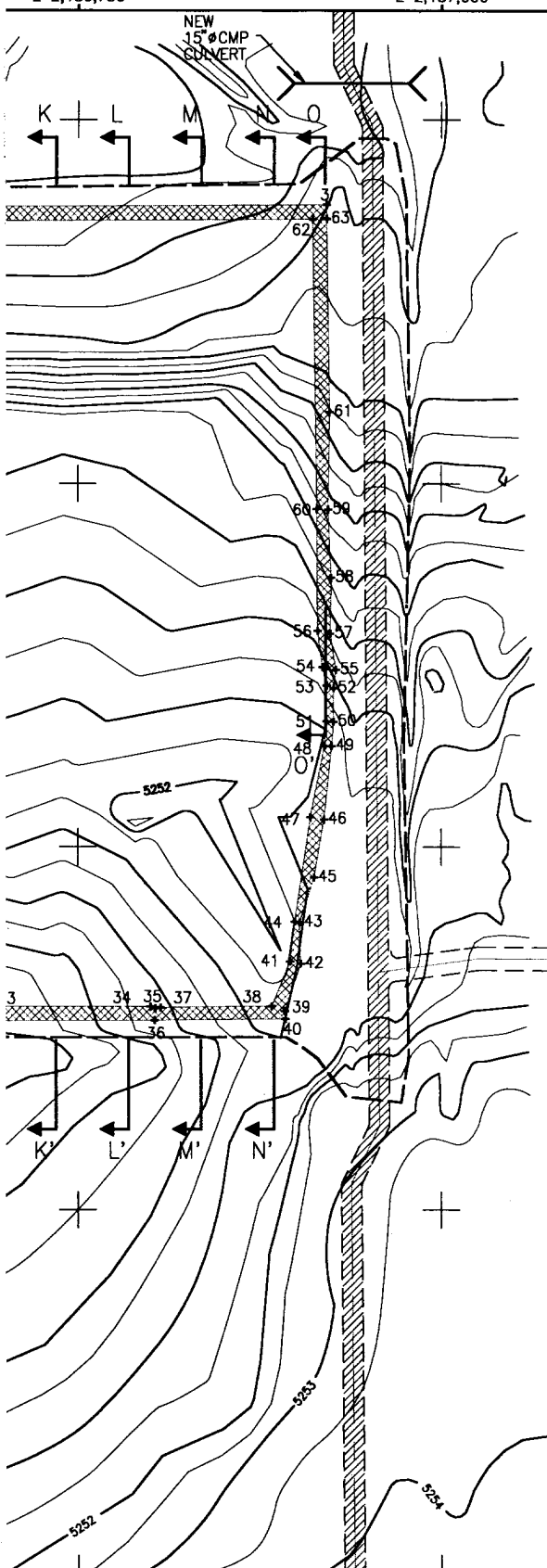
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LEGEND

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- 0.5 FT GRADING CONTOUR (COMPACTED LAYER)
- ===== PERMANENT SERVICE ROAD
- EXISTING DIRT/GRAVEL ROAD
- 3
62 63
SLURRY WALL CORRIDOR WITH COORDINATE POINT NUMBERS
- APPROXIMATE BOUNDARY OF DISTURBED AREA

SLURRY TRENCH CORRIDOR COORDINATES

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NOTES

- REFERENCE DRAWINGS 34-006 THRU 34-009 FOR COVER CROSS SECTIONS (A'-A THRU O'-O).
- REFERENCE DRAWINGS 34-004 & 34-005 FOR SLURRY WALL WORKING BENCH PLACEMENT & CONSTRUCTION SEQUENCE.

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DESIGNED BY: MFW 12/07/90
CHECKED BY: RLR 12/10/90

CLIENT APPROVALS
REV BY DATE



MORRISON KNUDSEN CORPORATION
ENVIRONMENTAL SERVICES GROUP

SHELL OIL COMPANY
ROCKY MOUNTAIN ARSENAL REMEDIATION PROJECT
INTERIM RESPONSE ACTION FINAL DETAILED DESIGN

CAD FILE NAME: 803C02A

SHELL SECTION 36 TRENCHES
INTERIM RESPONSE ACTION

DRAWING TITLE

COVER GRADING PLAN
COMPACTED LAYER

WORK ORDER

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DRAWING NO.

37803-34-002A

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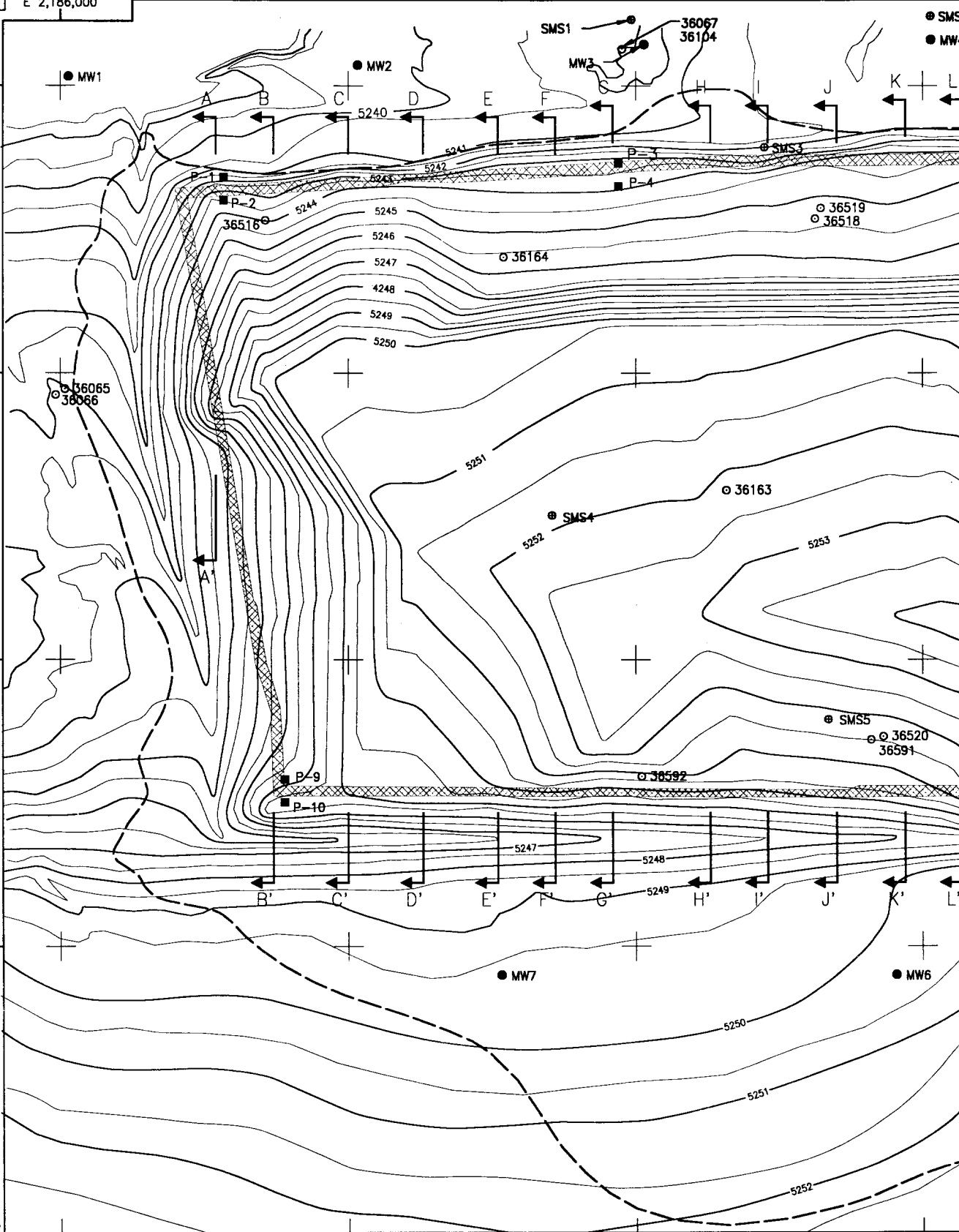
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| 34-003 | SOIL/GROUNDWATER MONITOR & ROAD DETAILS |
| 34-006 | COVER CROSS SECTIONS SHEET 1 |
| 34-007 | COVER CROSS SECTIONS SHEET 2 |
| 34-008 | COVER CROSS SECTIONS SHEET 3 |
| 34-009 | COVER CROSS SECTIONS SHEET 4 |

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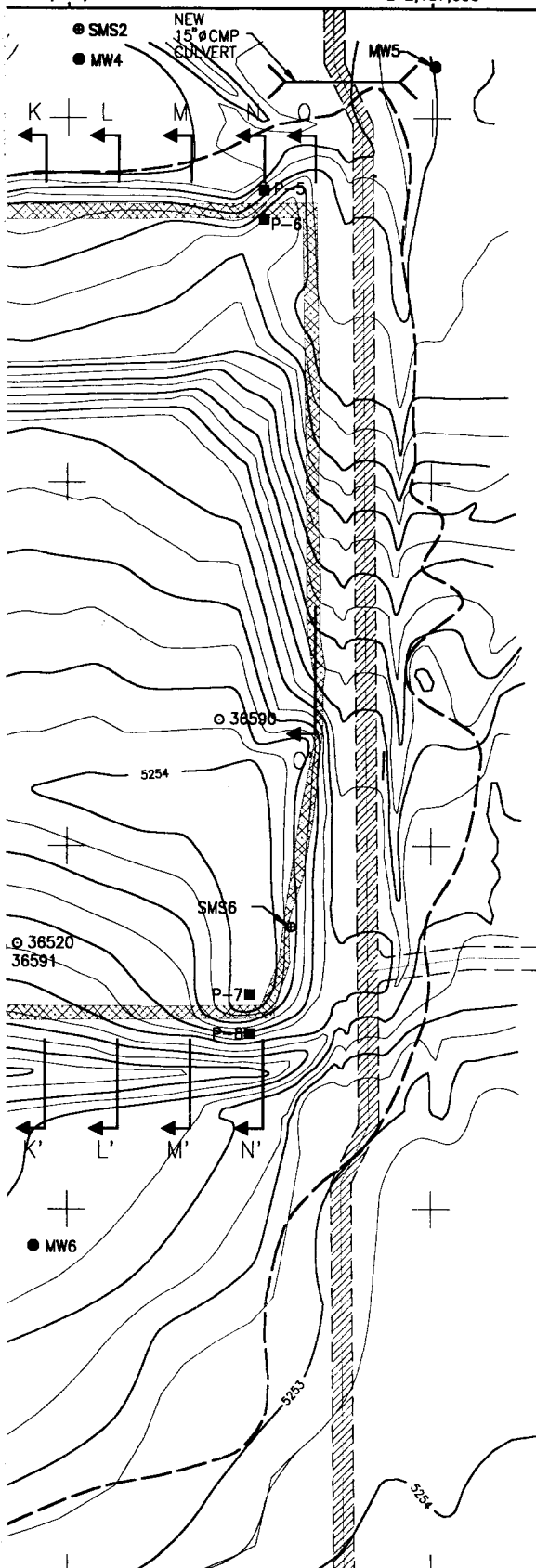
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LEGEND

- 5253 — 1 FT GRADING CONTOUR (TOPSOIL LAYER)
- 0.5 FT GRADING CONTOUR (TOPSOIL LAYER)
- PERMANENT SERVICE ROAD
- EXISTING DIRT/GRAVEL ROAD
- ⊙ SMS4 SOIL MOISTURE MONITORING STATION (NEW)
- 36163 WELLS TO BE ABANDONED
- P-5 PERMANENT PIEZOMETER (NEW)
- MW4 ALLUVIAL MONITORING WELL (NEW)
- SLURRY WALL CORRIDOR
- — — — — APPROXIMATE BOUNDARY OF DISTURBED AREA

NOTE:

1. TWO OF THE EXISTING WELLS TO BE ABANDONED, 36063 AND 36064 ARE LOCATED OUTSIDE OF THE MAP AREA. REFERENCE DRAWING 34-003.
2. REFERENCE DRAWINGS 34-006 THRU 34-009 FOR COVER CROSS-SECTIONS (A'-A THRU O'-O).

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MORRISON KNUDSEN CORPORATION
ENVIRONMENTAL SERVICES GROUP

SHELL OIL COMPANY

ROCKY MOUNTAIN ARSENAL REMEDIATION PROJECT
INTERIM RESPONSE ACTION FINAL DETAILED DESIGN

CAD FILE NAME: 803C02B0

SHELL SECTION 36 TRENCHES
INTERIM RESPONSE ACTION

DRAWING TITLE

COVER GRADING PLAN
TOPSOIL LAYER

WORK ORDER

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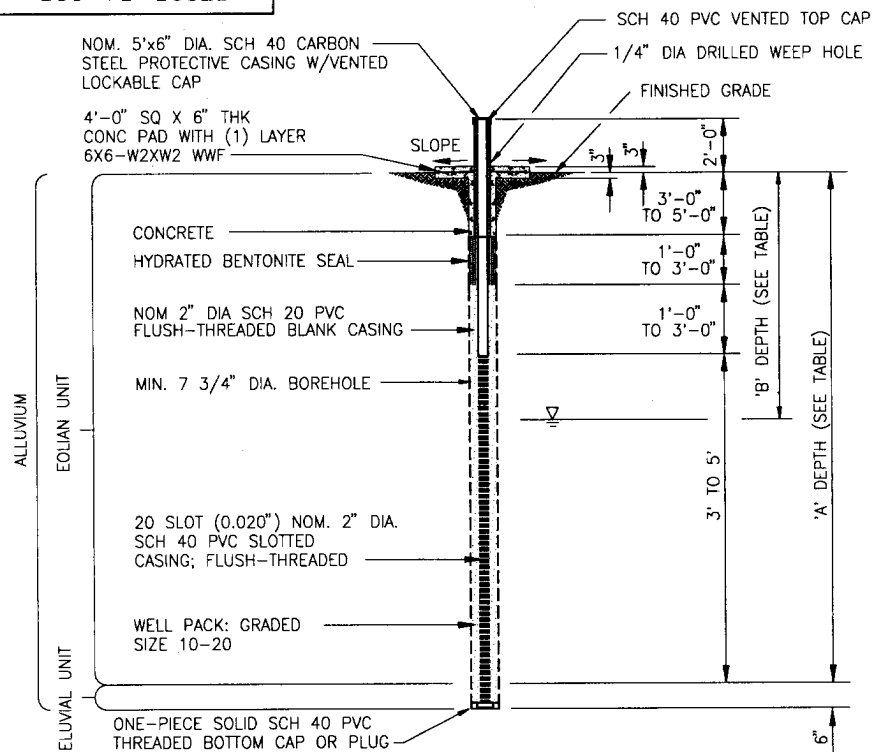
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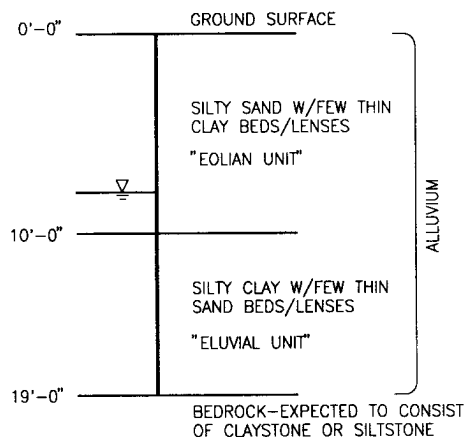
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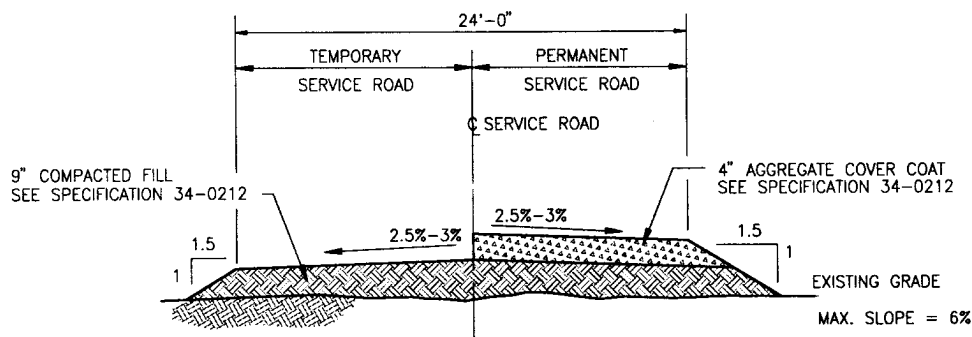
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x
34



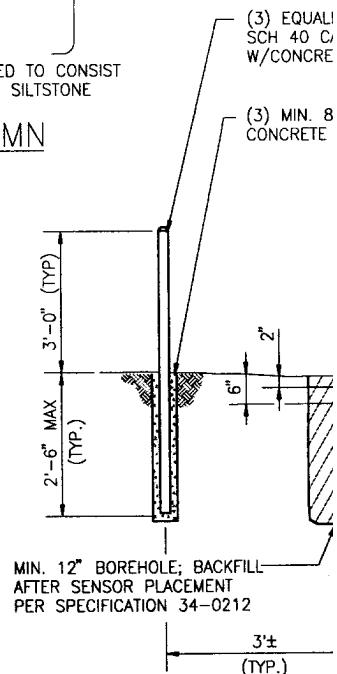
TYPICAL PERMANENT PIEZOMETER (P-X)
NO SCALE



TYPICAL GEOLOGIC COLUMN
VICINITY OF TRENCHES
(NO SCALE)

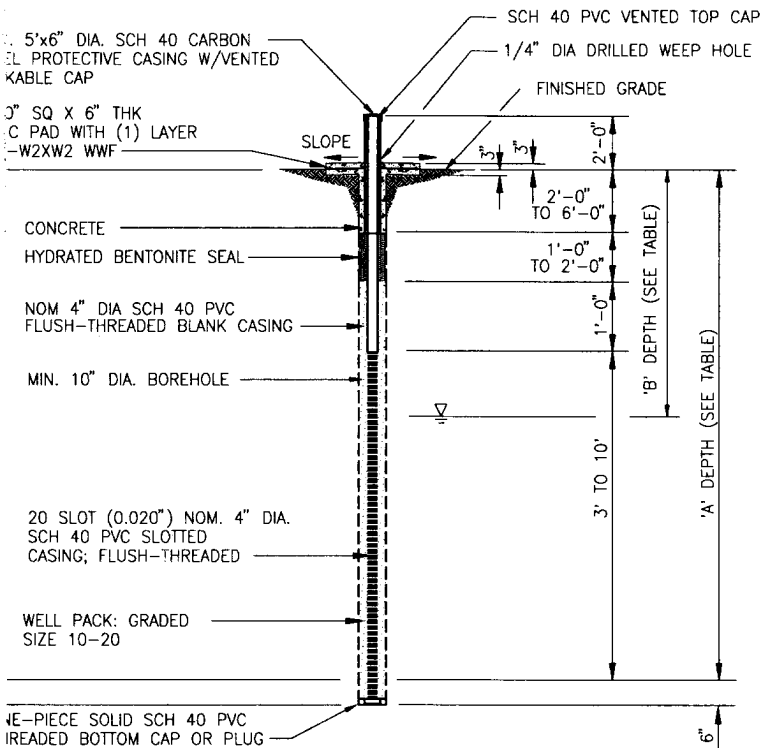


SECTION A
NO SCALE 34-001



TYPICAL SOIL MOISTURE M
NO SCALE

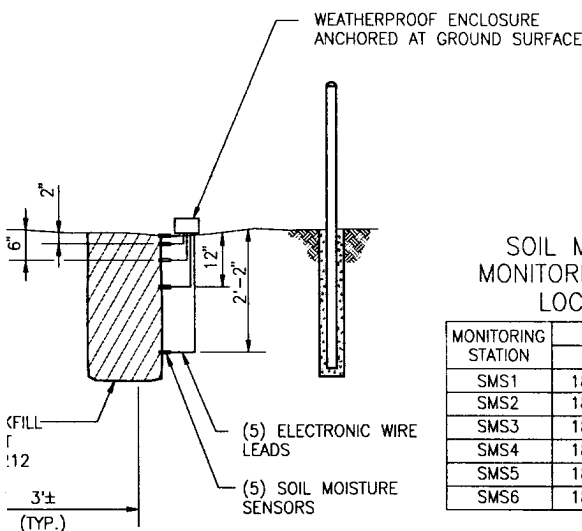
[illegible]



TYPICAL ALLUVIAL MONITORING WELL (MWX)
NOT TO SCALE

(3) EQUALLY SPACED 4\"/>

(3) MIN. 8\"/>



SOIL MOISTURE
MONITORING STATION
LOCATIONS

| MONITORING STATION | COORDINATES | |
|-----------------------|-------------|---------|
| | N | E |
| SMS1 | 182056 | 2186496 |
| SMS2 | 182061 | 2186757 |
| SMS3 | 181947 | 2186612 |
| SMS4 | 181626 | 2186427 |
| SMS5 | 181448 | 2186667 |
| SMS6 | 181444 | 2186904 |

SOIL MOISTURE MONITORING STATION (SMSX)

<CPD:2/26/91>

PERMANENT PIEZOMETERS

| PIEZOMETER | COORDINATES | | APPROX DEPTHS (FT) | |
|------------|-------------|---------|--------------------|------|
| | N | E | 'A' | 'B' |
| P-1 | 181920 | 2186142 | 14.3 | 8.4 |
| P-2 | 181900 | 2186142 | 15.4 | 9.4 |
| P-3 | 181942 | 2186485 | 12.0 | 8.8 |
| P-4 | 181922 | 2186485 | 12.7 | 9.4 |
| P-5 | 181950 | 2186885 | 9.5 | 10.2 |
| P-6 | 181930 | 2186885 | 10.5 | 11.2 |
| P-7 | 181397 | 2186876 | 11.3 | 11.5 |
| P-8 | 181377 | 2186876 | 8.8 | 9.1 |
| P-9 | 181395 | 2186195 | 11.2 | 7.2 |
| P-10 | 181375 | 2186195 | 11.0 | 7.5 |

ALLUVIAL MONITORING WELL

| PIEZOMETER | COORDINATES | | APPROX DEPTHS (FT) | |
|------------|-------------|---------|--------------------|------|
| | N | E | 'A' | 'B' |
| MW1 | 182008 | 2186007 | 10.7 | 4.5 |
| MW2 | 182018 | 2186258 | 9.5 | 6.3 |
| MW3 | 182036 | 2186507 | 10.1 | 7.6 |
| MW4 | 182040 | 2186757 | 9.0 | 7.9 |
| MW5 | 182035 | 2187002 | 8.0 | 10.5 |
| MW6 | 181225 | 2186727 | 6.0 | 7.1 |
| MW7 | 181225 | 2186383 | 7.1 | 6.6 |

WELL AND WELL POINT ABANDONMENT

| WELL | CASING DIA. (IN) | PROTECTIVE CASING | CASING | DEPTHS (FT) | | WATER |
|-------|---------------------|----------------------|--------|-------------|--------|-------|
| | | | | TOP | BOTTOM | |
| 36163 | 4 | YES | 16.5 | 10.7 | 16.5 | 9 |
| 36164 | 4 | YES | 13.0 | 7.5 | 13.0 | 9 |
| 36516 | 2 | YES | 21.5 | 6.5 | 21.5 | 8 |
| 36518 | 2 | YES | 14.2 | 9.2 | 14.2 | 8 |
| 36519 | 2 | YES | 11.3 | 6.3 | 11.3 | 8 |
| 36520 | 2 | YES | 9.0 | 4.0 | 9.0 | 6 |
| 36590 | 4 | NO | 28.0 | 18.0 | 28.0 | 10 |
| 36591 | 4 | NO | 28.0 | 18.0 | 28.0 | 6 |
| 36592 | 4 | NO | 28.0 | 18.0 | 28.0 | 5 |
| 36063 | 2 | NO | 23.7 | 18.3 | 21.7 | 16 |
| 36064 | 2 | NO | 119.0 | 70.2 | 73.6 | 14 |
| 36065 | 2 | NO | 24.0 | 17.6 | 21.0 | 8 |
| 36066 | 2 | NO | 114.0 | 73.3 | 76.7 | 12 |
| 36067 | 2 | NO | 24.5 | 10.4 | 13.4 | 7 |
| 36104 | 2 | NO | 112.7 | 92.0 | 99.0 | 16 |

NOTES:

- TEN EXISTING WELL POINTS CLUSTERED AROUND WELL 36519 SHALL BE ABANDONED. EACH WELL HAS A TOTAL DEPTH OF 10.8 FT.
- WELLS 36063 & 36064 ARE LOCATED OUTSIDE OF MAP AREA ON DWGS 34-001 AND 34-002B.
- SEE SPECIFICATION 34-0274 FOR WELL AND WELL POINT ABANDONMENT INFORMATION.
- SEE SPECIFICATION 34-0276 FOR PERMANENT PIEZOMETER CONSTRUCTION INFORMATION.
- SEE SPECIFICATION 34-0272 FOR ALLUVIAL MONITORING WELL CONSTRUCTION INFORMATION.
- SEE SPECIFICATION 34-0261 FOR SOIL MOISTURE MONITORING STATION CONSTRUCTION INFORMATION.

| | |
|------------------|---------|
| SCALE: AS NOTED | DATE |
| DRAWN BY: ERM | 12/7/90 |
| DESIGNED BY: AMB | 12/7/90 |
| CHECKED BY: RLR | 12/9/90 |

| CLIENT APPROVALS | | |
|------------------|----|------|
| REV | BY | DATE |
| | | |
| | | |
| | | |



MORRISON KNUDSEN CORPORATION
ENVIRONMENTAL SERVICES GROUP

SHELL OIL COMPANY

ROCKY MOUNTAIN ARSENAL REMEDIATION PROJECT
INTERIM RESPONSE ACTION FINAL DETAILED DESIGN

CAD FILE NAME: 803C0030

SHELL SECTION 36 TRENCHES
INTERIM RESPONSE ACTION

DRAWING TITLE

SOIL/GROUNDWATER
MONITORING & ROAD DETAILS

WORK ORDER
2127

DRAWING NO.

37803-34-003

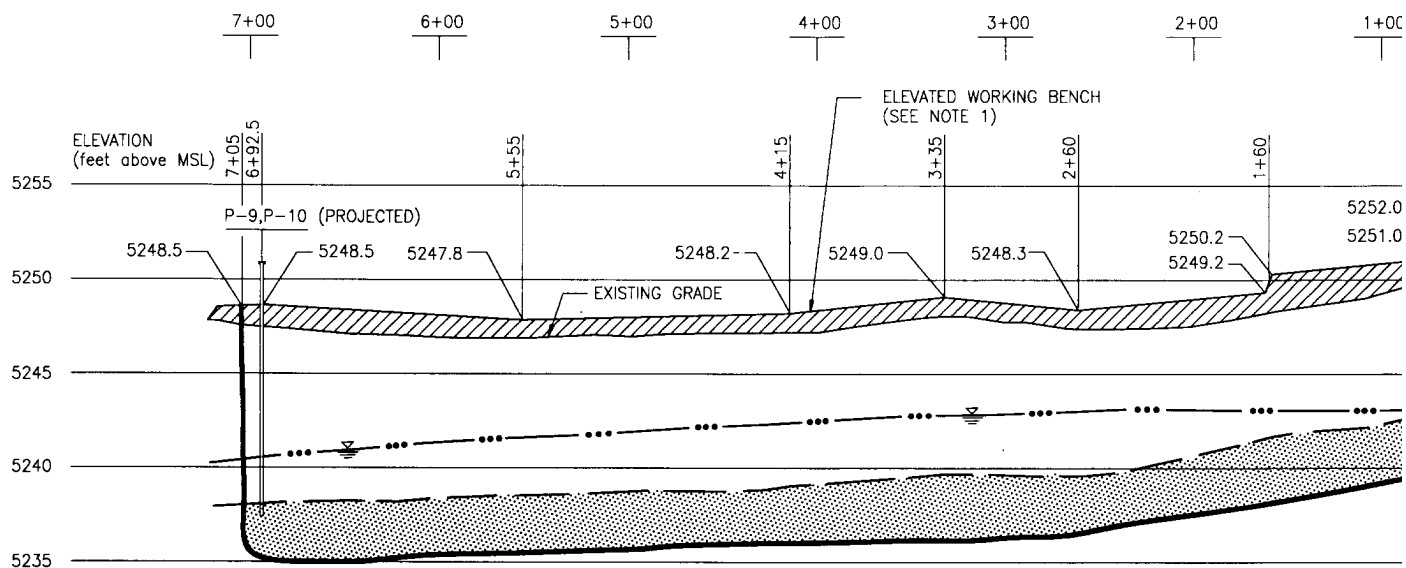
REFERENCE NO.

REV

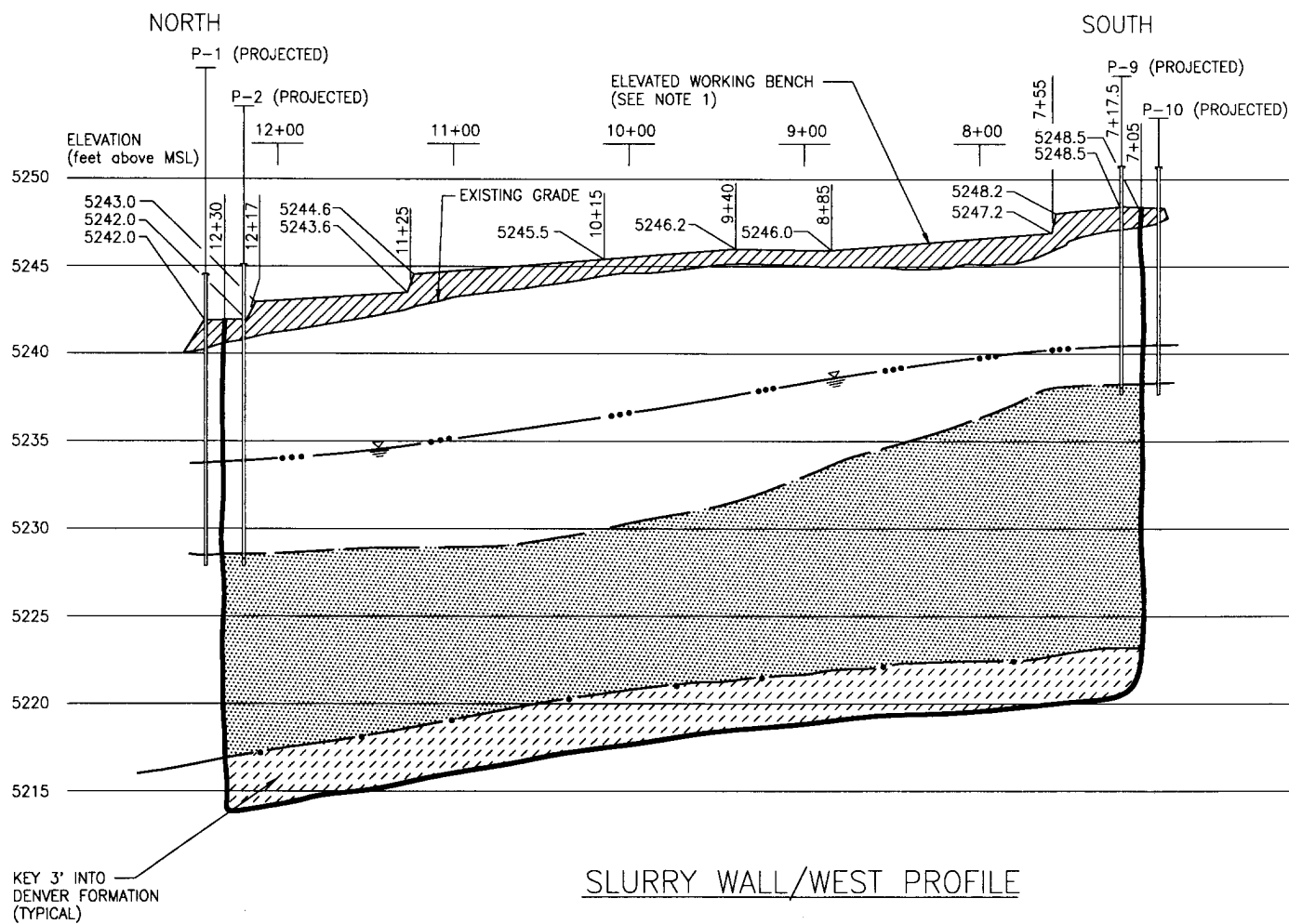
A

22
x
34

WEST

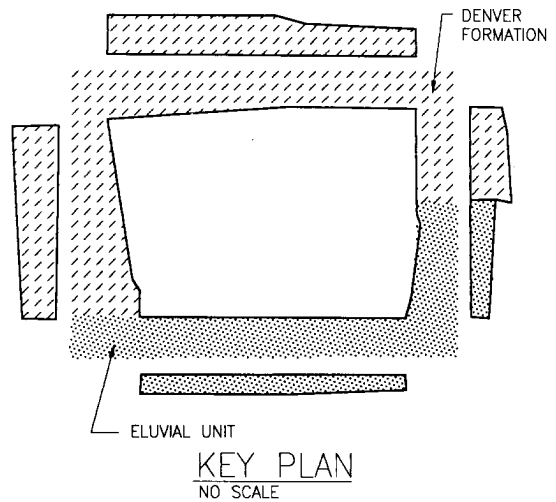
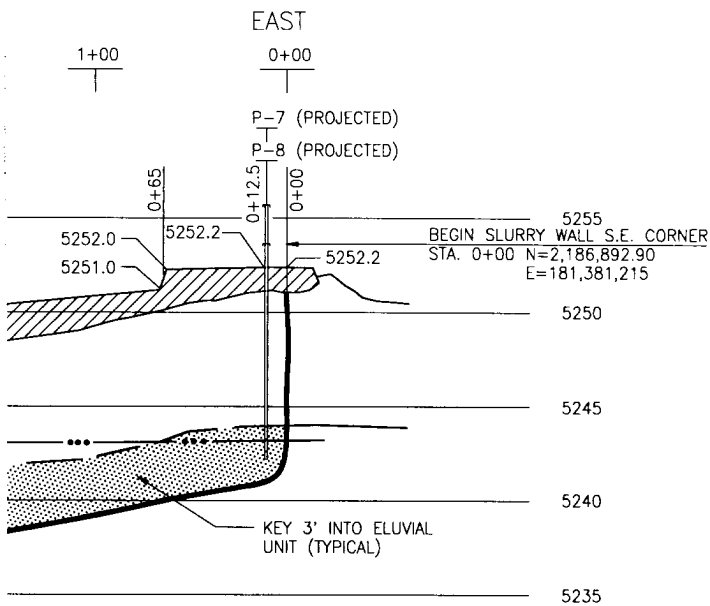


SLURRY WALL/SOUTH PROFILE



SLURRY WALL/WEST PROFILE

[illegible]



LEGEND:

- WORKING BENCH
- EOLIAN UNIT
- ELUVIAL UNIT
- DENVER FORMATION
- EXISTING GRADE (TOP OF EOLIAN UNIT)
- TOP OF ELUVIAL UNIT
- TOP OF DENVER FORMATION
- WATER TABLE

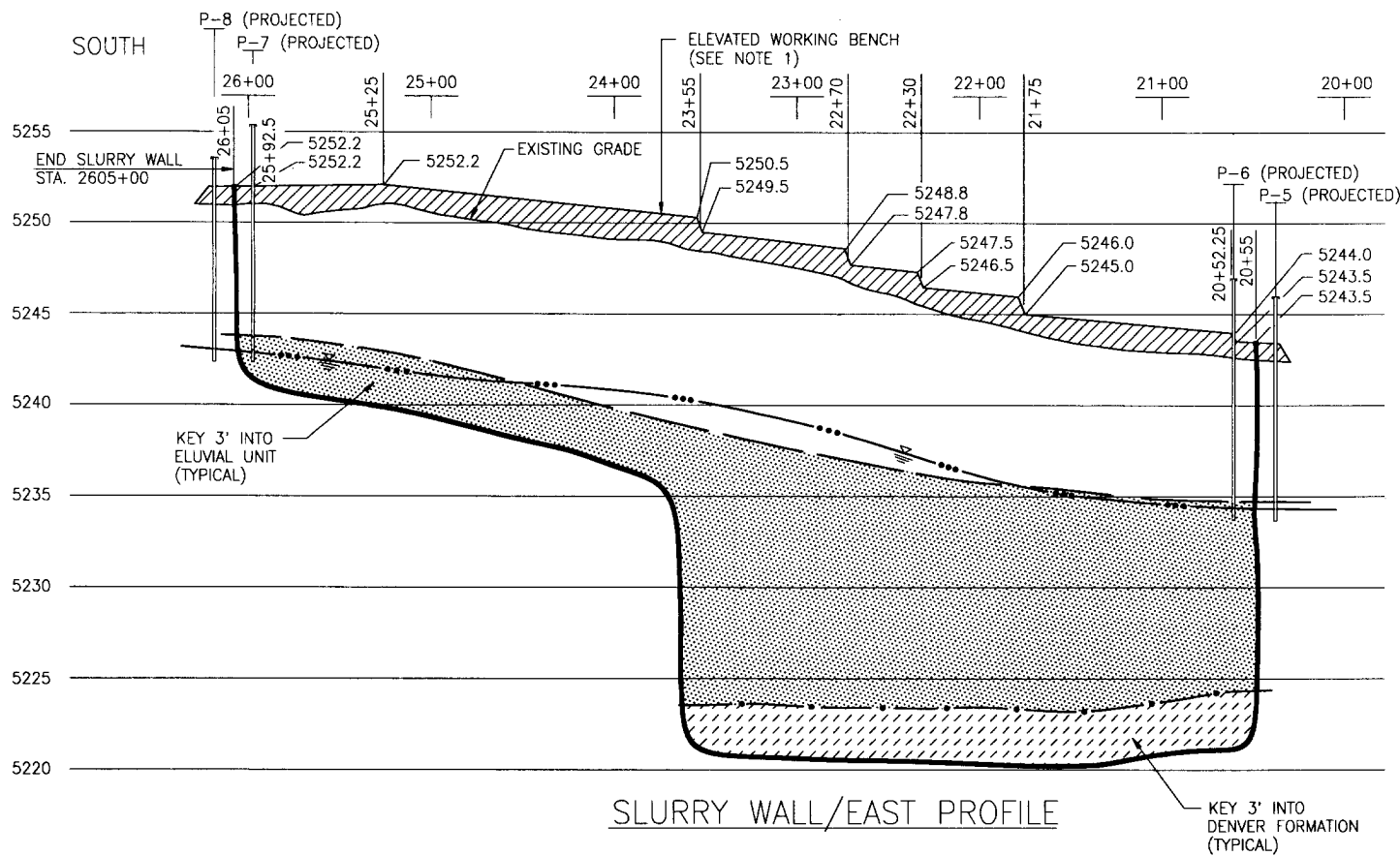
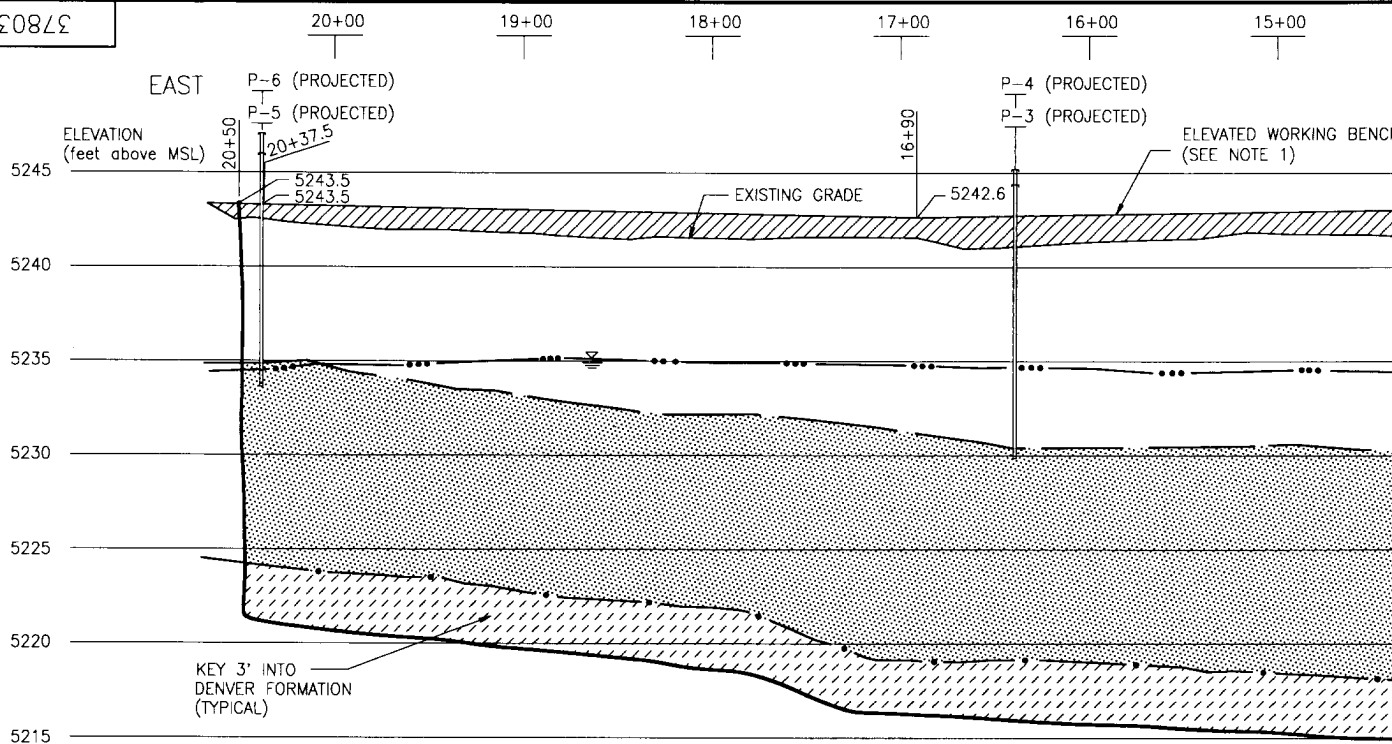
NOTES:

1. THE ELEVATED WORKING BENCH SHALL BE COMPACTED FILL PLACED PER SPECIFICATION 34-0212. THE WORKING BENCH SHALL BE REMOVED TO A HEIGHT OF APPROXIMATELY 6" ABOVE EXISTING GRADE FOLLOWING PLACEMENT OF THE SLURRY WALL. THE REMAINING PORTION OF THE WORKING BENCH SHALL COMPRISE PART OF THE COMPACTED LAYER, AS SHOWN ON DRAWING 34-002A.
2. PERMANENT PIEZOMETERS P-1 THROUGH P-10 SHALL BE OFFSET 10' FROM THE SLURRY WALL.
3. ABANDONMENT OF WELLS IN CLOSE PROXIMITY TO THE SLURRY WALL SHALL OCCUR PRIOR TO SLURRY WALL CONSTRUCTION.
4. THE HISTORICAL FLUCTUATION IN WATER TABLE ELEVATION IS $\pm 5'$.
5. STEPS IN WORKING BENCH TO HAVE A MAXIMUM HEIGHT OF 1'-0" AND A MAXIMUM SLOPE OF 1:1.
6. SEE SPECIFICATION 34-0263 FOR SLURRY WALL CONSTRUCTION INFORMATION.
7. WHERE STEPS IN WORKING BENCH ARE SHOWN, STATIONING IS REPORTED FOR MIDPOINT OF STEP SLOPE.
8. ESTIMATED ACCURACY IN STATIONING = $\pm 5'$, EXCEPT WHERE OFFSET OF EDGE OF WORKING BENCH WITH RESPECT TO SLURRY WALL INTERCEPT IS SHOWN.

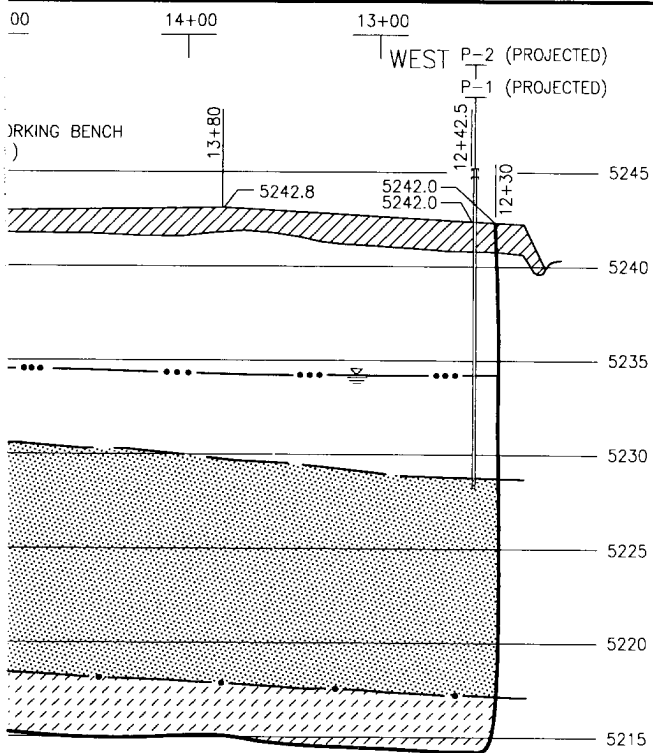
<CPD:2/26/91>

| | | | | | | | | | | |
|-------------------------|----|---------|---|---|--|--|--|---------------|--|---------------|
| SCALE: AS NOTED | | DATE | | MORRISON KNUDSEN CORPORATION ENVIRONMENTAL SERVICES GROUP | | SHELL SECTION 36 TRENCHES INTERIM RESPONSE ACTION | | WORK ORDER | | 22 x 34 |
| DRAWN BY: ERM | | 12/9/90 | | | | | | 2127 | | |
| DESIGNED BY: MFW | | 12/7/90 | | | | | | DRAWING NO. | | |
| CHECKED BY: RLR | | 12/9/90 | | | | | | 37803-34-004 | | |
| CLIENT APPROVALS | | | | SHELL OIL COMPANY ROCKY MOUNTAIN ARSENAL REMEDIATION PROJECT INTERIM RESPONSE ACTION FINAL DETAILED DESIGN | | DRAWING TITLE SLURRY WALL PROFILE & DETAILS SHEET 1 | | REFERENCE NO. | | REV |
| REV | BY | DATE | 0 | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| CAD FILE NAME: 803C0040 | | | | | | | | | | |

37803-34-005



| | | | | | | | | | | | | | | | | | |
|----------------|--------------------------------------|----|-----------|----------|-----|---------------------------------|--|--|---------|-----------|------------|----------|-----|-----|--|-----------|----------|
| REFERENCE DWGS | | | REVISIONS | | | | | | | APPROVALS | DEPT / REV | A | 0 | | | SCALE: AS | |
| | | | | | | | | | | | | ARCH | | | | | DRAWN BY |
| | | | | | | | | | | | | CIV/STRL | RLR | RLR | | | DESIGNED |
| | | | | | | | | | | | | MECH | | | | | CHECKED |
| | | | | | | | | | | | | ELECT | | | | | CLIENT |
| | | | | | | | | | | | | INSTM | | | | | REV |
| | | | | | | | | | | | | PIPING | | | | | |
| | | | | | | | | | | | | SAFETY | | | | | |
| | | | | | | | | | | | | PROCESS | | | | | |
| | | | | | | | | | | | | DEPT MGR | | | | | |
| | | | | | | | | | PROJECT | MFW | MFW | | | | | | |
| 34-002A | COVER GRADING PLAN / COMPACTED LAYER | 0 | DAP | 3/1/91 | RLR | ISSUED FOR FINAL IMPLEMENTATION | | | | | | | | | | | |
| 34-002B | COVER GRADING PLAN / TOPSOIL LAYER | A | DAP | 12/20/90 | RLR | ISSUED FOR REVIEW & COMMENT | | | | | | | | | | | |
| DRAWING NO. | TITLE | NO | BY | DATE | CKD | DESCRIPTION | | | | | | | | | | | |

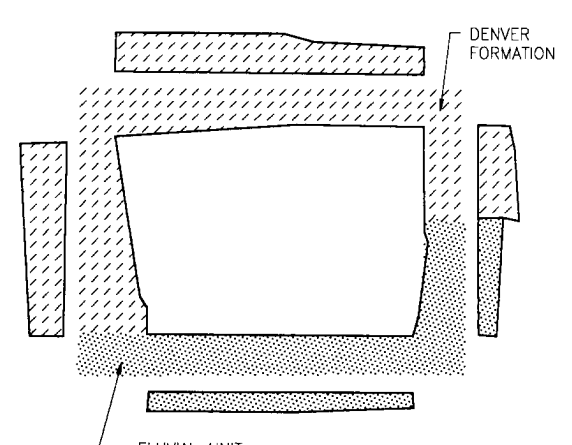


PROFILE

NORTH



FORMATION



KEY PLAN
NO SCALE

LEGEND:

- WORKING BENCH
- EOLIAN UNIT
- ELUVIAL UNIT
- DENVER FORMATION
- EXISTING GRADE (TOP OF EOLIAN UNIT)
- TOP OF ELUVIAL UNIT
- TOP OF DENVER FORMATION
- WATER TABLE

NOTES:

1. THE ELEVATED WORKING BENCH SHALL BE COMPACTED FILL PLACED PER SPECIFICATION 34-0212. THE WORKING BENCH SHALL BE REMOVED TO A HEIGHT OF APPROXIMATELY 6" ABOVE EXISTING GRADE FOLLOWING PLACEMENT OF THE SLURRY WALL. THE REMAINING PORTION OF THE WORKING BENCH SHALL COMPRISE PART OF THE COMPACTED LAYER, AS SHOWN ON DRAWING 34-002A.
2. PERMANENT PIEZOMETERS P-1 THROUGH P-10 SHALL BE OFFSET 10' FROM THE SLURRY WALL.
3. ABANDONMENT OF WELLS IN CLOSE PROXIMITY TO THE SLURRY WALL SHALL OCCUR PRIOR TO SLURRY WALL CONSTRUCTION.
4. THE HISTORICAL FLUCTUATION IN WATER TABLE ELEVATION IS $\pm 5'$.
5. STEPS IN WORKING BENCH TO HAVE A MAXIMUM HEIGHT OF 1'-0" AND A MAXIMUM SLOPE OF 1:1.
6. SEE SPECIFICATION 34-0263 FOR SLURRY WALL CONSTRUCTION INFORMATION.
7. WHERE STEPS IN WORKING BENCH ARE SHOWN, STATIONING IS REPORTED FOR MIDPOINT OF STEP SLOPE.
8. ESTIMATED ACCURACY IN STATIONING = $\pm 5'$, EXCEPT WHERE OFFSET OF EDGE OF WORKING BENCH WITH RESPECT TO SLURRY WALL INTERCEPT IS SHOWN.

<CPD:2/26/91>

| | | | | | | | | | | |
|-------------------------|----|---------|--|---|--|--|--|---------------|--|---------------|
| SCALE: AS NOTED | | DATE | | MORRISON KNUDSEN CORPORATION ENVIRONMENTAL SERVICES GROUP | | SHELL SECTION 36 TRENCHES INTERIM RESPONSE ACTION | | WORK ORDER | | 22 x 34 |
| DRAWN BY: ERM | | 12/9/90 | | | | | | 2127 | | |
| DESIGNED BY: MFW | | 12/7/90 | | | | | | DRAWING NO. | | |
| CHECKED BY: RLR | | 12/9/90 | | | | | | 37803-34-005 | | |
| CLIENT APPROVALS | | | | SHELL OIL COMPANY ROCKY MOUNTAIN ARSENAL REMEDIATION PROJECT INTERIM RESPONSE ACTION FINAL DETAILED DESIGN | | DRAWING TITLE SLURRY WALL PROFILE & DETAILS SHEET 2 | | REFERENCE NO. | | REV |
| REV | BY | DATE | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| CAD FILE NAME: 803C0050 | | | | | | | | | | 0 |

COMPACTED LAYER SURFACE A'-A

| E | N | ELEV. (msl) |
|-----------|----------|----------------|
| 2186139.7 | 181697.2 | 5244.5 |
| 2186139.7 | 181703.2 | 5245.1 |
| 2186139.7 | 181760.2 | 5244.8 |
| 2186139.7 | 181934.2 | 5241.2 |
| 2186139.7 | 181938.2 | 5240.5 |

COMPACTED LAYER SURFACE B'-B

| E | N | ELEV. (msl) |
|-----------|----------|----------------|
| 2186189.7 | 181367.2 | 5247.5 |
| 2186189.7 | 181373.2 | 5248.2 |
| 2186189.7 | 181457.2 | 5246.8 |
| 2186189.7 | 181792.2 | 5247.2 |
| 2186189.7 | 181820.2 | 5244.6 |
| 2186189.7 | 181929.2 | 5241.2 |
| 2186189.7 | 181931.2 | 5240.8 |

COMPACTED LAYER SURFACE C'-C

| E | N | ELEV. (msl) |
|-----------|----------|----------------|
| 2186254.7 | 181370.2 | 5247.3 |
| 2186254.7 | 181375.2 | 5247.6 |
| 2186254.7 | 181418.2 | 5246.7 |
| 2186254.7 | 181788.2 | 5247.6 |
| 2186254.7 | 181900.2 | 5242.5 |
| 2186254.7 | 181933.2 | 5242.0 |
| 2186254.7 | 181937.2 | 5241.3 |

COMPACTED LAYER SURFACE D'-D

| E | N | ELEV. (msl) |
|-----------|----------|----------------|
| 2186319.7 | 181370.2 | 5247.4 |
| 2186319.7 | 181374.2 | 5247.6 |
| 2186319.7 | 181408.2 | 5247.0 |
| 2186319.7 | 181600.2 | 5249.2 |
| 2186319.7 | 181792.2 | 5247.6 |
| 2186319.7 | 181900.2 | 5242.4 |
| 2186319.7 | 181934.2 | 5241.7 |
| 2186319.7 | 181938.2 | 5241.2 |

SOUTH

ELEVATION
(feet above MSL)

5245

5242.5

5240

UNCOMPACTED VEGETATED LAYER
(TYPICAL)

COMPACTED LAYER (TYPICAL)

EXISTING GRADE

SLURRY WALL
(TYPICAL)

SECTION A'

CUT/FILL TO EXISTING
GRADE (TYPICAL)INVERT FOR DRAINAGE
TO WEST (TYPICAL)

P-10 P-9

MAX. 7.5%

5247.5

5245

5242.5

SECTION B'

5247.5

5245

5242.5

SECTION C'

5250

5247.5

5245

5242.5

SECTION D'

HORIZONTAL
SCALE IN FEET

0 12.5' 25' 50'

(TYP)

REFERENCE DWGS

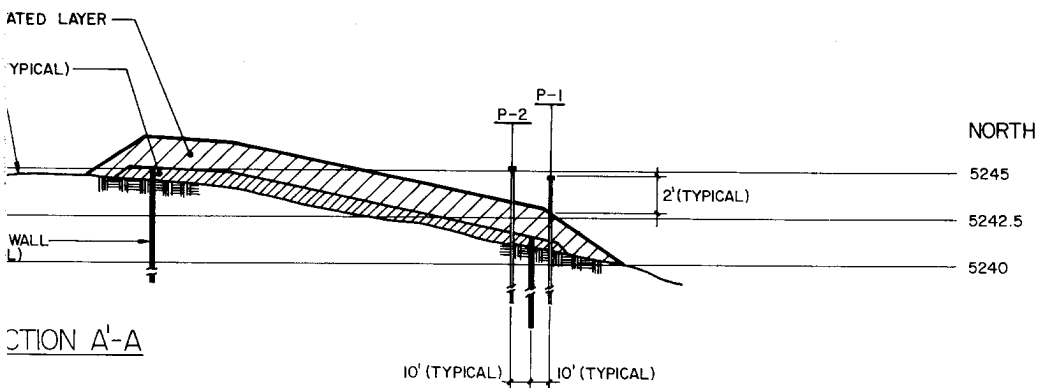
| | |
|-------------|------------------------------------|
| 34-002B | COVER GRADING PLAN/TOPSOIL LAYER |
| 34-002A | COVER GRADING PLAN/COMPACTED LAYER |
| DRAWING NO. | TITLE |

REVISIONS

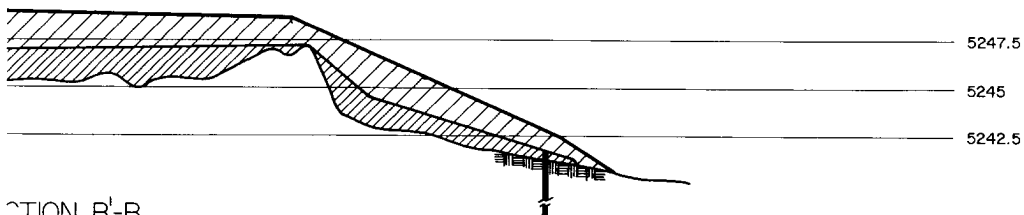
| NO | BY | DATE | CKD | DESCRIPTION |
|----|-----|----------|-----|---------------------------------|
| 0 | BM | 3/1/91 | RLR | ISSUED FOR FINAL IMPLEMENTATION |
| A | DAP | 12/20/90 | RLR | ISSUED FOR REVIEW & COMMENT |

APPROVALS

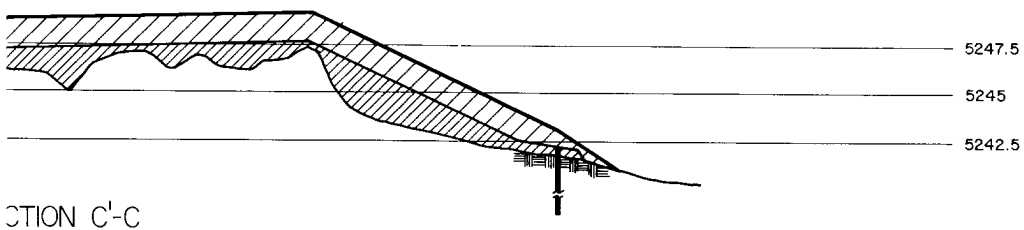
| DEPT / REV | A | O | SCALE: H:V |
|------------|-----|-----|------------|
| ARCH | | | DRAWN BY |
| CIV/STRL | RLR | RLR | DESIGNED |
| MECH | | | CHECKED |
| ELECT | | | CLIENT |
| INSTM | | | REV |
| PIPING | | | |
| SAFETY | | | |
| PROCESS | | | |
| DEPT MGR | | | |
| PROJECT | MFW | MFW | |



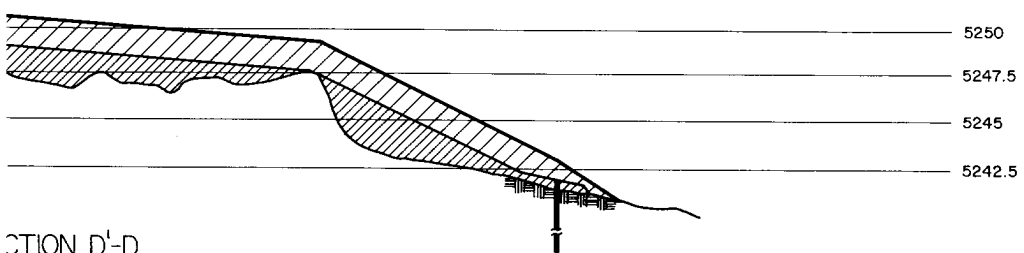
| TOPSOIL SURFACE A'-A | | |
|----------------------|----------|-------------|
| E | N | ELEV. (msl) |
| 2186139.7 | 181682.2 | 5244.7 |
| 2186139.7 | 181711.2 | 5246.7 |
| 2186139.7 | 181760.2 | 5246.5 |
| 2186139.7 | 181925.2 | 5242.9 |
| 2186139.7 | 181964.2 | 5240.2 |



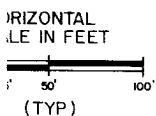
| TOPSOIL SURFACE B'-B | | |
|----------------------|----------|-------------|
| E | N | ELEV. (msl) |
| 2186189.7 | 181335.2 | 5245.8 |
| 2186189.7 | 181378.2 | 5249.5 |
| 2186189.7 | 181750.2 | 5248.5 |
| 2186189.7 | 181922.2 | 5242.4 |
| 2186189.7 | 181951.2 | 5240.6 |



| TOPSOIL SURFACE C'-C | | |
|----------------------|----------|-------------|
| E | N | ELEV. (msl) |
| 2186254.7 | 181335.2 | 5246.0 |
| 2186254.7 | 181371.2 | 5248.4 |
| 2186254.7 | 181789.2 | 5249.3 |
| 2186254.7 | 181920.2 | 5243.1 |
| 2186254.7 | 181953.2 | 5240.9 |



| TOPSOIL SURFACE D'-D | | |
|----------------------|----------|-------------|
| E | N | ELEV. (msl) |
| 2186319.7 | 181335.2 | 5246.3 |
| 2186319.7 | 181385.2 | 5248.3 |
| 2186319.7 | 181600.2 | 5250.8 |
| 2186319.7 | 181792.2 | 5249.3 |
| 2186319.7 | 181921.2 | 5243.0 |
| 2186319.7 | 181952.2 | 5240.9 |



NOTE: SEE DRAWING 34-002B FOR PIEZOMETER LOCATIONS.

LEGEND

- TOPSOIL LAYER
- COMPACTED LAYER

| | |
|---------------------------|---------|
| SCALE: H: 1"=50' V: 1"=5' | DATE |
| DRAWN BY: ERM | 12/9/90 |
| DESIGNED BY: MFW | 12/9/90 |
| CHECKED BY: RLR | 12/9/90 |
| CLIENT APPROVALS | |
| REV | BY DATE |
| | |
| | |
| | |
| | |



MORRISON KNUDSEN CORPORATION
ENVIRONMENTAL SERVICES GROUP

SHELL OIL COMPANY

ROCKY MOUNTAIN ARSENAL REMEDIATION PROJECT
INTERIM RESPONSE ACTION FINAL DETAILED DESIGN

CAD FILE NAME:

SHELL SECTION 36 TRENCHES
INTERIM RESPONSE ACTION

DRAWING TITLE

COVER CROSS SECTIONS
SHEET 1

WORK ORDER
2127

DRAWING NO.

37803-34-006

REFERENCE NO.

22
X
34

REV
0

COMPACTED LAYER SURFACE E'-E

| E | N | ELEV. (msl) |
|-----------|----------|----------------|
| 2186384.7 | 181370.2 | 5247.5 |
| 2186384.7 | 181373.2 | 5247.8 |
| 2186384.7 | 181415.2 | 5247.8 |
| 2186384.7 | 181584.2 | 5249.7 |
| 2186384.7 | 181793.2 | 5248.2 |
| 2186384.7 | 181828.2 | 5244.0 |
| 2186384.7 | 181878.2 | 5242.8 |
| 2186384.7 | 181943.2 | 5241.8 |
| 2186384.7 | 181955.2 | 5241.0 |

SOUTH

ELEVATION
(feet above MSL)

5250

5247.5

5245

5242.5

INVERT FOR DRAINAGE
TO WEST (TYPICAL)

CUT/FILL TO EXISTING
GRADE (TYPICAL)

UNCOMPACTED VEGETATED LAYER
(TYPICAL)

COMPACTED LAYER (TYPICAL)

EXISTING GRADE

MAX.
7.5%SLURRY WALL
(TYPICAL)

SECTION E

COMPACTED LAYER SURFACE F'-F

| E | N | ELEV. (msl) |
|-----------|----------|----------------|
| 2186434.7 | 181366.2 | 5247.4 |
| 2186434.7 | 181373.2 | 5247.9 |
| 2186434.7 | 181564.2 | 5250.2 |
| 2186434.7 | 181795.2 | 5248.3 |
| 2186434.7 | 181832.2 | 5244.4 |
| 2186434.7 | 181898.2 | 5242.5 |
| 2186434.7 | 181945.2 | 5241.8 |
| 2186434.7 | 181956.2 | 5241.0 |

5250

5247.5

5245

5242.5

SECTION F

COMPACTED LAYER SURFACE G'-G

| E | N | ELEV. (msl) |
|-----------|----------|----------------|
| 2186484.7 | 181365.2 | 5247.5 |
| 2186484.7 | 181372.2 | 5247.9 |
| 2186484.7 | 181395.2 | 5248.1 |
| 2186484.7 | 181416.2 | 5249.5 |
| 2186484.7 | 181481.2 | 5250.0 |
| 2186484.7 | 181799.2 | 5248.2 |
| 2186484.7 | 181839.2 | 5244.0 |
| 2186484.7 | 181892.2 | 5242.5 |
| 2186484.7 | 181948.2 | 5241.7 |
| 2186484.7 | 181963.2 | 5240.8 |

5250

5247.5

5245

5242.5

SECTION G

COMPACTED LAYER SURFACE H'-H

| E | N | ELEV. (msl) |
|-----------|----------|----------------|
| 2186569.7 | 181365.2 | 5247.7 |
| 2186569.7 | 181372.2 | 5248.3 |
| 2186569.7 | 181544.2 | 5250.7 |
| 2186569.7 | 181787.2 | 5248.9 |
| 2186569.7 | 181840.2 | 5244.4 |
| 2186569.7 | 181953.2 | 5241.7 |
| 2186569.7 | 181959.2 | 5241.2 |

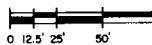
5250

5247.5

5245

5242.5

SECTION H

HORIZONTAL
SCALE IN FEET

(TYP)

REFERENCE DWGS

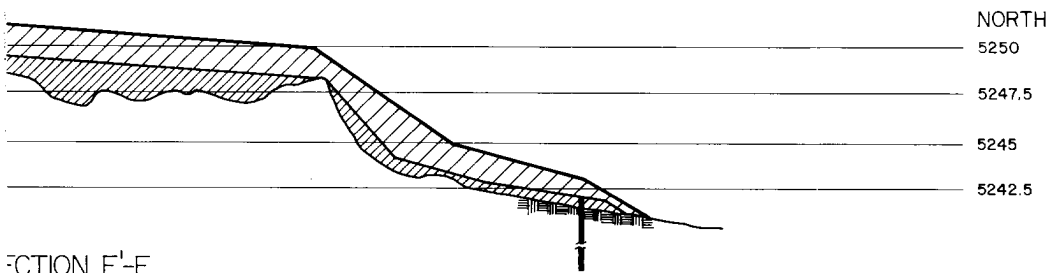
| | |
|-------------|------------------------------------|
| 34-002B | COVER GRADING PLAN/TOPSOIL LAYER |
| 34-002A | COVER GRADING PLAN/COMPACTED LAYER |
| DRAWING NO. | TITLE |

REVISIONS

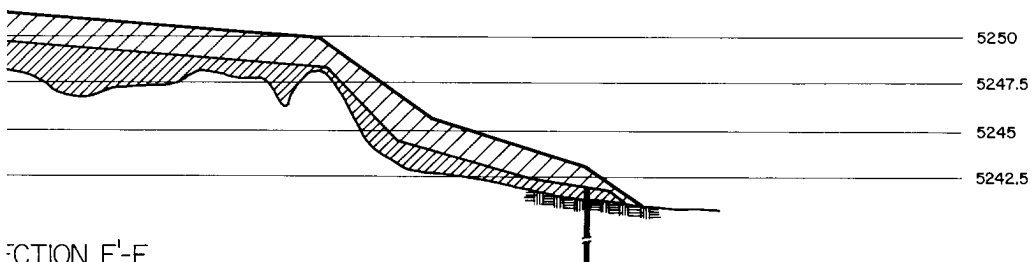
| NO | BY | DATE | CKD | DESCRIPTION |
|----|-----|----------|-----|---------------------------------|
| 0 | BM | 3/1/91 | RLR | ISSUED FOR FINAL IMPLEMENTATION |
| A | DAP | 12/20/90 | RLR | ISSUED FOR REVIEW & COMMENT |

APPROVALS

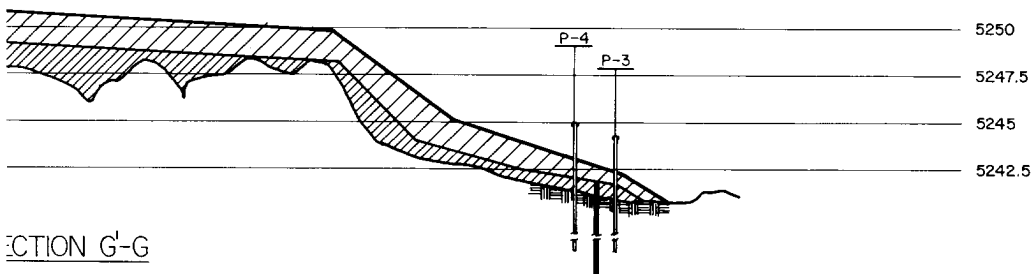
| DEPT / REV | A | O | SCALE: H:V |
|------------|-----|-----|------------|
| ARCH | | | DRAWN BY |
| CIV/STRL | RLR | RLR | DESIGNED |
| MECH | | | CHECKED |
| ELECT | | | CLIENT |
| INSTM | | | REV |
| PIPING | | | |
| SAFETY | | | |
| PROCESS | | | |
| DEPT MGR | | | |
| PROJECT | MFW | MFW | |



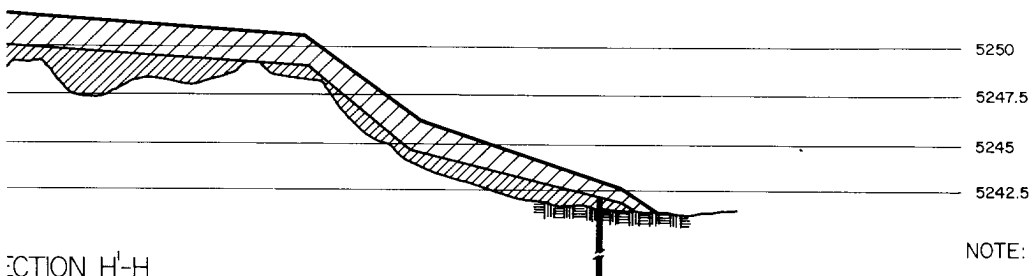
| TOPSOIL SURFACE E'-E | | |
|----------------------|----------|----------------|
| E | N | ELEV. (msl) |
| 2186384.7 | 181335.2 | 5246.0 |
| 2186384.7 | 181386.2 | 5249.1 |
| 2186384.7 | 181585.2 | 5251.4 |
| 2186384.7 | 181785.2 | 5250.0 |
| 2186384.7 | 181860.2 | 5244.8 |
| 2186384.7 | 181929.2 | 5243.0 |
| 2186384.7 | 181966.2 | 5240.8 |



| TOPSOIL SURFACE F'-F | | |
|----------------------|----------|----------------|
| E | N | ELEV. (msl) |
| 2186434.7 | 181335.2 | 5246.8 |
| 2186434.7 | 181402.2 | 5249.9 |
| 2186434.7 | 181564.2 | 5251.8 |
| 2186434.7 | 181790.2 | 5249.9 |
| 2186434.7 | 181850.2 | 5245.6 |
| 2186434.7 | 181933.2 | 5243.0 |
| 2186434.7 | 181962.2 | 5240.8 |

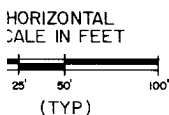


| TOPSOIL SURFACE G'-G | | |
|----------------------|----------|----------------|
| E | N | ELEV. (msl) |
| 2186484.7 | 181335.2 | 5247.0 |
| 2186484.7 | 181432.2 | 5251.9 |
| 2186484.7 | 181795.2 | 5249.9 |
| 2186484.7 | 181860.2 | 5245.1 |
| 2186484.7 | 181950.2 | 5242.2 |
| 2186484.7 | 181975.2 | 5240.7 |



| TOPSOIL SURFACE H'-H | | |
|----------------------|----------|----------------|
| E | N | ELEV. (msl) |
| 2186569.7 | 181335.2 | 5247.3 |
| 2186569.7 | 181407.2 | 5250.5 |
| 2186569.7 | 181544.2 | 5252.4 |
| 2186569.7 | 181784.2 | 5250.6 |
| 2186569.7 | 181844.2 | 5246.1 |
| 2186569.7 | 181951.2 | 5242.5 |
| 2186569.7 | 181970.2 | 5241.2 |

NOTE: SEE DRAWING 34-002B FOR PIEZOMETER LOCATIONS.



LEGEND

- TOPSOIL LAYER
- COMPACTED LAYER

| | | |
|----------------------|---------|------|
| SCALE: H:V=50':1"=5' | | DATE |
| DRAWN BY: ERM | 12/9/90 | |
| DESIGNED BY: MFW | 12/9/90 | |
| CHECKED BY: RLR | 12/9/90 | |
| CLIENT APPROVALS | | |
| REV | BY | DATE |
| | | |
| | | |
| | | |
| | | |



MORRISON KNUDSEN CORPORATION
ENVIRONMENTAL SERVICES GROUP

SHELL OIL COMPANY

ROCKY MOUNTAIN ARSENAL-REMEDIATION PROJECT
INTERIM RESPONSE ACTION FINAL DETAILED DESIGN

CAD FILE NAME:

SHELL SECTION 36 TRENCHES
INTERIM RESPONSE ACTION

DRAWING TITLE

COVER CROSS SECTIONS
SHEET 2

| | | |
|---------------|--------------|---------------|
| WORK ORDER | 2127 | 22 x 34 |
| DRAWING NO. | 37803-34-007 | |
| REFERENCE NO. | | REV 0 |

COMPACTED LAYER SURFACE 1'-1

| E | N | FLEV (msl) |
|-----------|----------|---------------|
| 2186619.7 | 181360.2 | 5247.4 |
| 2186619.7 | 181373.2 | 5248.0 |
| 2186619.7 | 181399.2 | 5248.2 |
| 2186619.7 | 181550.2 | 5251.2 |
| 2186619.7 | 181728.2 | 5249.0 |
| 2186619.7 | 181757.2 | 5249.0 |
| 2186619.7 | 181797.2 | 5248.6 |
| 2186619.7 | 181839.2 | 5244.5 |
| 2186619.7 | 181910.2 | 5242.5 |
| 2186619.7 | 181952.2 | 5242.0 |
| 2186619.7 | 181960.2 | 5241.5 |

COMPACTED LAYER SURFACE J'-J

| E | N | ELEV. (msl) |
|-----------|----------|----------------|
| 2186679.7 | 181361.2 | 5247.4 |
| 2186679.7 | 181372.2 | 5247.9 |
| 2186679.7 | 181406.2 | 5248.0 |
| 2186679.7 | 181521.2 | 5251.7 |
| 2186679.7 | 181799.2 | 5248.8 |
| 2186679.7 | 181842.2 | 5244.3 |
| 2186679.7 | 181913.2 | 5242.5 |
| 2186679.7 | 181951.2 | 5242.3 |
| 2186679.7 | 181960.2 | 5241.7 |

COMPACTED LAYER SURFACE K'-K

| E | N | ELEV. (msl) |
|-----------|----------|----------------|
| 2186739.7 | 181368.2 | 5248.1 |
| 2186739.7 | 181373.2 | 5248.5 |
| 2186739.7 | 181417.2 | 5248.8 |
| 2186739.7 | 181543.2 | 5251.7 |
| 2186739.7 | 181795.2 | 5248.7 |
| 2186739.7 | 181843.2 | 5244.2 |
| 2186739.7 | 181913.2 | 5242.5 |
| 2186739.7 | 181955.2 | 5242.3 |
| 2186739.7 | 181965.2 | 5241.7 |

COMPACTED LAYER SURFACE L'-L

| E | N | ELEV. (msl) |
|-----------|----------|----------------|
| 2186789.7 | 181362.2 | 5248.7 |
| 2186789.7 | 181373.2 | 5249.5 |
| 2186789.7 | 181405.2 | 5249.7 |
| 2186789.7 | 181501.2 | 5251.3 |
| 2186789.7 | 181515.2 | 5252.6 |
| 2186789.7 | 181800.2 | 5248.5 |
| 2186789.7 | 181845.2 | 5244.0 |
| 2186789.7 | 181957.2 | 5242.4 |
| 2186789.7 | 181967.2 | 5241.7 |

A cross-section diagram of a road profile. The vertical axis on the left is labeled 'ELEVATION (feet above MSL)' with values 5250, 5247.5, 5245, and 5242.5. The horizontal axis is labeled 'SOUTH'. The profile shows a road surface sloping downwards from left to right at a 'MAX. 7.5%' grade. A 'CUT/FILL TO EXISTING GRADE (TYPICAL)' is indicated on the left side. A 'DRAINAGE INVERT' is shown as a vertical line with a cross-hatched area representing the drainage structure. An arrow points to the invert with the text 'INVERT FOR DRAINAGE TO WEST (TYPICAL)'.

SECTION 1'-

5252.5
5250
5247.5
5245
5242.5

SECTION J'


5252.5
5250
5247.5
5245
5242.5

SECTION K

5252.5
5250
5247.5
5245
5242.5

SECTION L'

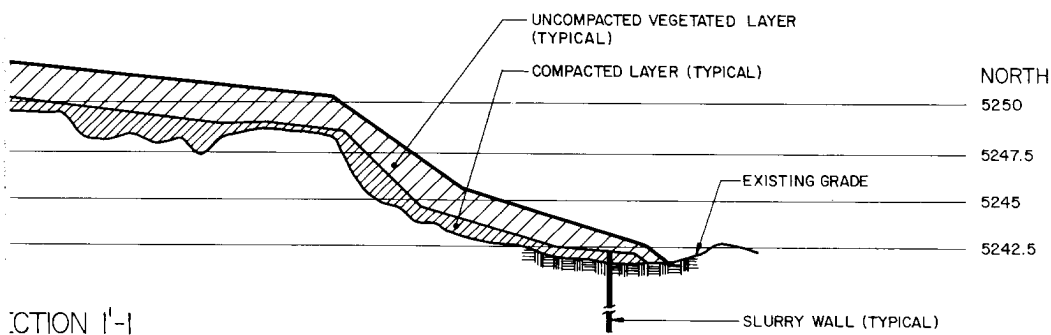
HORIZONTAL
SCALE IN FEET



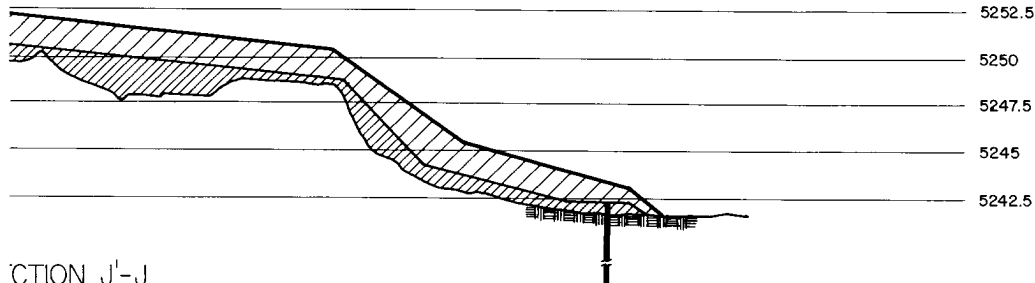
0 12.5' 25' 50'

(TYP)

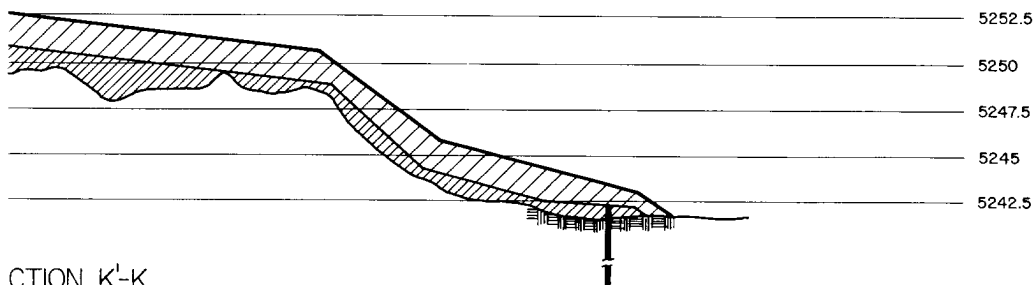
[illegible]



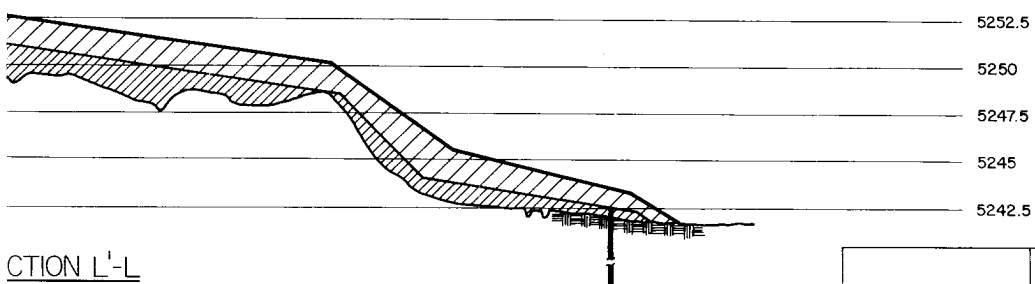
| TOPSOIL SURFACE I'-I | | |
|----------------------|----------|-------------|
| E | N | ELEV. (msl) |
| 2186619.7 | 181335.2 | 5247.5 |
| 2186619.7 | 181405.2 | 5250.0 |
| 2186619.7 | 181549.2 | 5252.9 |
| 2186619.7 | 181791.2 | 5250.4 |
| 2186619.7 | 181860.2 | 5245.5 |
| 2186619.7 | 181957.2 | 5242.5 |
| 2186619.7 | 181970.2 | 5241.6 |



| TOPSOIL SURFACE J'-J | | |
|----------------------|----------|-------------|
| E | N | ELEV. (msl) |
| 2186679.7 | 181335.2 | 5247.8 |
| 2186679.7 | 181521.2 | 5253.4 |
| 2186679.7 | 181793.2 | 5250.5 |
| 2186679.7 | 181863.2 | 5245.5 |
| 2186679.7 | 181951.2 | 5243.2 |
| 2186679.7 | 181971.2 | 5241.7 |



| TOPSOIL SURFACE K'-K | | |
|----------------------|----------|-------------|
| E | N | ELEV. (msl) |
| 2186739.7 | 181335.2 | 5248.0 |
| 2186739.7 | 181385.2 | 5249.6 |
| 2186739.7 | 181543.2 | 5253.4 |
| 2186739.7 | 181787.2 | 5250.5 |
| 2186739.7 | 181852.2 | 5245.7 |
| 2186739.7 | 181956.2 | 5243.0 |
| 2186739.7 | 181975.2 | 5241.7 |



| TOPSOIL SURFACE L'-L | | |
|----------------------|----------|-------------|
| E | N | ELEV. (msl) |
| 2186789.7 | 181335.2 | 5248.3 |
| 2186789.7 | 181388.2 | 5251.0 |
| 2186789.7 | 181529.2 | 5254.0 |
| 2186789.7 | 181795.2 | 5250.2 |
| 2186789.7 | 181860.2 | 5245.5 |
| 2186789.7 | 181955.2 | 5243.3 |
| 2186789.7 | 181979.2 | 5241.6 |

HORIZONTAL SCALE IN FEET

 (TYP)

LEGEND

- TOPSOIL LAYER
- COMPACTED LAYER

| | |
|---------------------------|---------|
| SCALE: H:V=50':1" V:1"=5' | DATE |
| DRAWN BY: ERM | 12/9/90 |
| DESIGNED BY: MFW | 12/9/90 |
| CHECKED BY: RLR | 12/9/90 |
| CLIENT APPROVALS | |
| REV | BY DATE |
| | |
| | |
| | |
| | |



MORRISON KNUDSEN CORPORATION
 ENVIRONMENTAL SERVICES GROUP

SHELL OIL COMPANY

ROCKY MOUNTAIN ARSENAL REMEDIATION PROJECT
 INTERIM RESPONSE ACTION FINAL DETAILED DESIGN

CAD FILE NAME:

SHELL SECTION 36 TRENCHES
 INTERIM RESPONSE ACTION

DRAWING TITLE

COVER CROSS SECTIONS
 SHEET 3

WORK ORDER
 2127

DRAWING NO.

37803-34-008

REFERENCE NO.

22
 x
 34

REV
 0

COMPACTED LAYER SURFACE M'-M

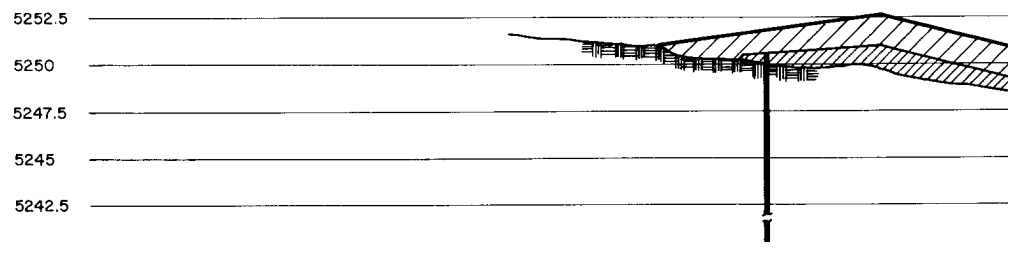
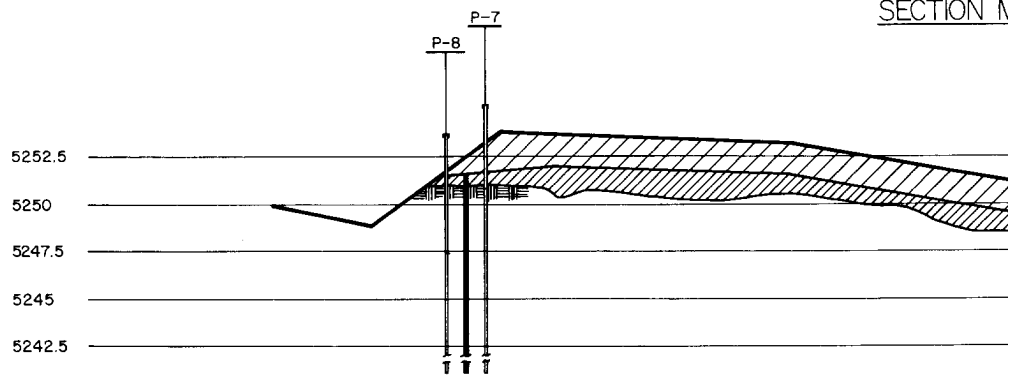
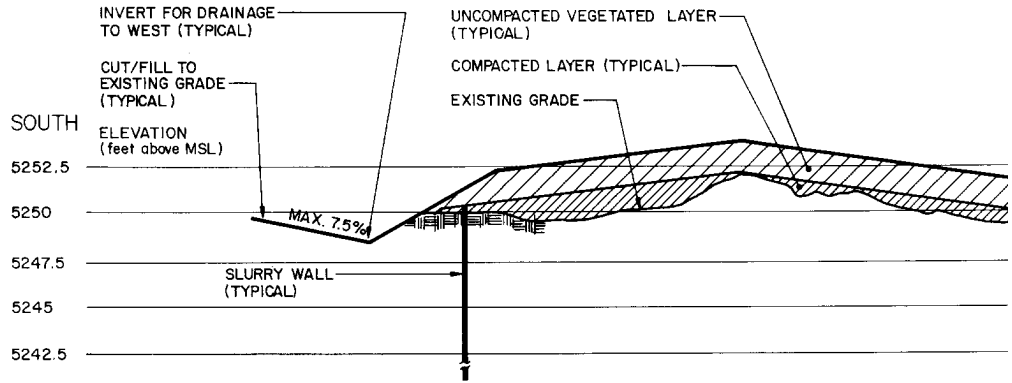
| E | N | ELEV. (msl) |
|-----------|----------|----------------|
| 2186839.7 | 181367.2 | 5249.9 |
| 2186839.7 | 181372.2 | 5250.3 |
| 2186839.7 | 181535.2 | 5252.2 |
| 2186839.7 | 181803.2 | 5248.5 |
| 2186839.7 | 181840.2 | 5244.7 |
| 2186839.7 | 181890.2 | 5243.5 |
| 2186839.7 | 181955.2 | 5242.6 |
| 2186839.7 | 181964.2 | 5242.0 |

COMPACTED LAYER SURFACE N'-N

| E | N | ELEV. (msl) |
|-----------|----------|----------------|
| 2186889.7 | 181368.2 | 5251.0 |
| 2186889.7 | 181374.2 | 5251.4 |
| 2186889.7 | 181428.2 | 5252.0 |
| 2186889.7 | 181559.2 | 5251.7 |
| 2186889.7 | 181759.2 | 5248.2 |
| 2186889.7 | 181849.2 | 5244.6 |
| 2186889.7 | 181953.2 | 5242.8 |
| 2186889.7 | 181960.2 | 5242.3 |

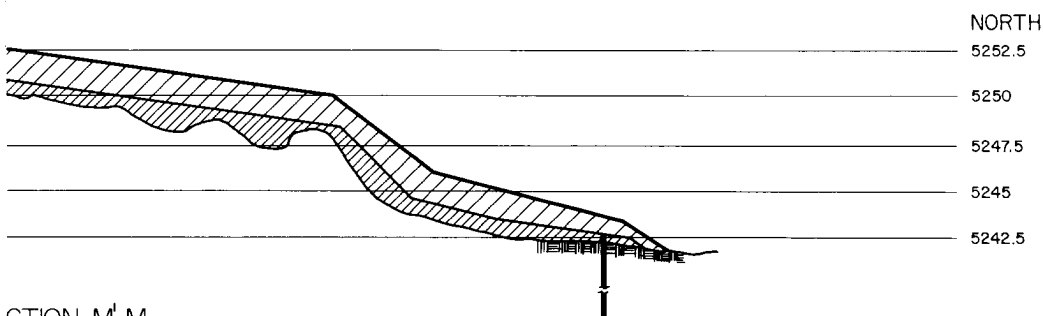
COMPACTED LAYER SURFACE O'-O

| E | N | ELEV. (msl) |
|-----------|----------|----------------|
| 2186924.7 | 181509.2 | 5250.1 |
| 2186924.7 | 181513.2 | 5250.4 |
| 2186924.7 | 181584.2 | 5250.9 |
| 2186924.7 | 181835.2 | 5244.6 |
| 2186924.7 | 181966.2 | 5243.9 |

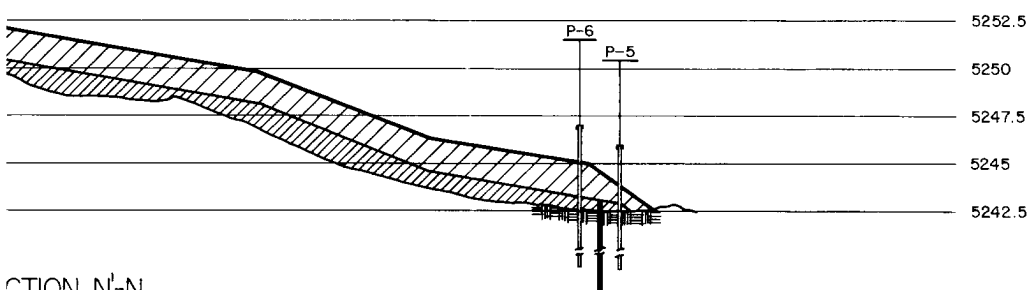


HORIZONTAL
SCALE IN FEET
0 12.5' 25' 50'
(TYP)

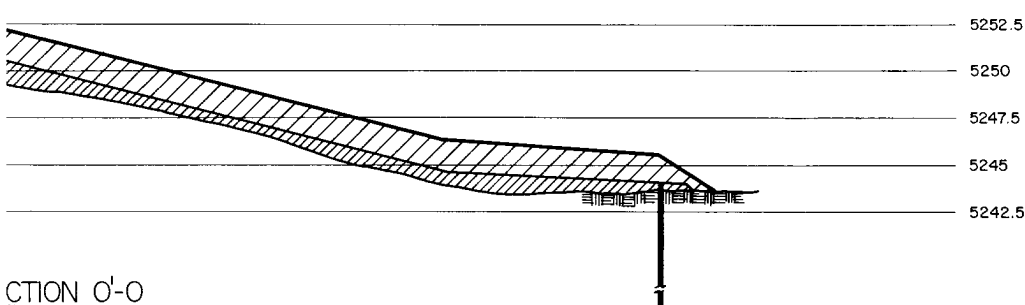
| REFERENCE DWGS | | | REVISIONS | | | | | APPROVALS | DEPT / REV | | A | O | | | SCALE: 1" |
|----------------|--|--------------------------------------|-----------|----|-----|----------|-----|---------------------------------|------------|---------|-----|-----|--|----------|-----------|
| | | | | | | | | | ARCH | | | | | DRAWN | |
| | | | | | | | | | CIV/STRL | RLR | RLR | | | DESIGNED | |
| | | | | | | | | | MECH | | | | | CHECKED | |
| | | | | | | | | | ELECT | | | | | CI | |
| | | | | | | | | | INSTM | | | | | REV | |
| | | | | | | | | | PIPING | | | | | | |
| | | | | | | | | | SAFETY | | | | | | |
| | | | | | | | | | PROCESS | | | | | | |
| | | | | | | | | | DEPT MGR | | | | | | |
| DRAWING NO. | | TITLE | | NO | BY | DATE | CKD | DESCRIPTION | | PROJECT | MFV | MFV | | | |
| 34-002B | | COVER GRADING PLAN / TOPSOIL LAYER | | O | BM | 3/1/91 | RLR | ISSUED FOR FINAL IMPLEMENTATION | | | | | | | |
| 34-002A | | COVER GRADING PLAN / COMPACTED LAYER | | A | DAP | 12/20/90 | RLR | ISSUED FOR REVIEW & COMMENT | | | | | | | |



| TOPSOIL SURFACE M'-M | | |
|----------------------|----------|-----------------|
| E | N | ELEV. (masl) |
| 2186839.7 | 181335.2 | 5248.5 |
| 2186839.7 | 181405.2 | 5252.4 |
| 2186839.7 | 181535.2 | 5253.9 |
| 2186839.7 | 181798.2 | 5250.2 |
| 2186839.7 | 181852.2 | 5246.0 |
| 2186839.7 | 181955.2 | 5243.3 |
| 2186839.7 | 181977.2 | 5241.8 |



| TOPSOIL SURFACE N'-N | | |
|----------------------|----------|-----------------|
| E | N | ELEV. (masl) |
| 2186889.7 | 181335.2 | 5248.8 |
| 2186889.7 | 181402.2 | 5253.8 |
| 2186889.7 | 181559.2 | 5253.4 |
| 2186889.7 | 181760.2 | 5249.9 |
| 2186889.7 | 181848.2 | 5246.3 |
| 2186889.7 | 181933.2 | 5245.3 |
| 2186889.7 | 181970.2 | 5242.5 |



| TOPSOIL SURFACE O'-O | | |
|----------------------|----------|-----------------|
| E | N | ELEV. (masl) |
| 2186924.7 | 181467.2 | 5251.0 |
| 2186924.7 | 181584.2 | 5252.6 |
| 2186924.7 | 181835.2 | 5246.3 |
| 2186924.7 | 181952.2 | 5245.5 |
| 2186924.7 | 181984.2 | 5243.5 |

HORIZONTAL
SCALE IN FEET
25' 50' 100'
(TYP)

NOTE: SEE DRAWING 34-002B FOR PIEZOMETER
LOCATIONS.

LEGEND

- TOPSOIL LAYER
- COMPACTED LAYER

| | | | | | | | |
|---|--|--|---|--|-----------------------------|--|--------------------|
| SCALE: H:1"=50' V:1"=5' DRAWN BY: ERM 12/9/90 DESIGNED BY: MFW 12/9/90 CHECKED BY: RLR 12/9/90 | | | MORRISON KNUDSEN CORPORATION ENVIRONMENTAL SERVICES GROUP | | WORK ORDER 2127 | | 22 x 34 |
| CLIENT APPROVALS REV BY DATE | | | SHELL OIL COMPANY ROCKY MOUNTAIN ARSENAL REMEDIATION PROJECT INTERIM RESPONSE ACTION FINAL DETAILED DESIGN | | DRAWING NO. 37803-34-009 | | |
| CAD FILE NAME: | | | DRAWING TITLE COVER CROSS SECTIONS SHEET 4 | | | | REFERENCE NO. 0 |